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THE EFFECT OF POST - WEANING STIMULATION ON EMOTIONALITY IN TWO STRAINS OF MICE

By

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled " The Effect of Post-Weaning Stimulation on Emotionality in Two Strains of Mice", submitted by Leendert Pieter Mos in Partial fulfillment of the requirements for the degree of Master of Science.

Abstract

Eighty mice from two emotionally divergent inbred strains, SWR/J and BALB/cJ, were subjected to four intensities of post-weaning stimulation. Each of the experimental groups contained an equal number of male and female subjects. At 50 days of age these animals were administered a battery of tasks consisting of 24 measures of emotionality. Each measure was analyzed by analysis of variance design with main effects for strain, sex, treatment and days.

Not all tasks in the battery were found to be sensitive to strain and treatment differences in emotionality. On the tasks that were, the effect due to strain, treatment, and strain by treatment were found to be statistically significant. The direction of the effect of increasing the intensity of post-weaning stimulation was different for the two strains of mice. The high-emotional BALB/cJ strain increased emotional reactivity, while the low-emotional SWR/J strain decreased emotional reactivity under treatment conditions of increasing intensity of stimulation. Strain differences in the expression of emotional reactivity became more pronounced in response to post-weaning stimulation.

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Introduction

General considerations

The purpose of this research is to study the effects of prior stressful stimulation on the emotionality of two strains of mice when subjected to a variety of novel situations (emotionality test battery). This undertaking was designed to provide information concerning:

1. The general effects of prior stressful stimulation, it situational generality and temporal persistence.
2. The importance of genotype as a determinant of emotionality.
3. The effect of genotype upon the relation between prior stress and later emotionality.

The idea that experiential events in the life of an organism can modulate the limits of its subsequent behavior is of long standing. In particular Freud (1933) explained the origin of neurosis in adult human patients as the result of intensive traumatic experience in infancy and early childhood. Numerous clinical reports tend to substantiate Freud's observations. Greenacre (1952), Spitz (1951), Ribble (1944) and others have reported observations on children which indicate the importance of infantile experience on the development of behavior patterns. In general these early experiences, along with hereditary dispositions, are considered to determine the manner in which the individual reacts in later situations. Additional evidence regarding the importance of early experience

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comes from the comparative study of primitive cultures. Tribes using relatively similar practices in nursing, weaning, toilet training etc., appear to have similar typical personalities even though the geographic circumstances in which they live might be expected to dictate different types of personality (Hunt, 1941; Mead, 1935; Roheim, 1934).

Although these two lines of evidence have been productive in initiating research, three defects are evident in their nature. First, they lack the predictive aspect desirable in scientific evidence. Second, there is little or no control of other factors which might operate in determining the observed characteristics. Third, seldom is there any way to supply a control group wherein the conditions under consideration are definitely absent. However, if some of the experiences considered important by psychoanalysis are among fundamental biological processes, their effects should be demonstrable upon lower animals as well as human beings (Hunt, 1941).

It is at this point that research in the area of behavior-genetics becomes particularly relevant. Studies of emotional behavior were among the earliest in this area (Fuller and Thompson, 1960). Phillips (1912) observed behavioral differences on wildness in mallard and black ducks and their hybrids. Yerkes (1913 observed behavioral differences on wildness, savageness and timidity in captured wild rats and tame hooded rats. The contrast between these

two parent lines, he pointed out, was extremely marked and could definitely be attributed to genetic factors. Coburn (1922) extended the work of Yerkes using mice instead of rats. The wild gray and tame strains which he used exhibited striking differences in ratings for the traits of wildness and savageness. These early studies used ratings to differentiate between strains of animals with respect to behavior characteristics.

Dawson (1932) studied the inheritance of wildness and tameness in mice, using an objective measure, the average time taken to traverse a 22-foot runway in three trials. He found marked behavioral differences between genotypes indicating the influence of hereditary factors. Research fluorished with the development of new objective measures: stovepipe, Stone (1932); open field, Hall (1934); under-water swimming, Broadhurst (1957, 1958); straightaway, Levine (1959); avoidance conditioning, Royce and Covington (1960).

It is of interest to note that behavior-genetic research and its concern with genetic differences has developed quite apart from comparative research generally within psychology and its concern with environmental effects until the late 1950's. "It is patent...that environmental influence must be an influence <u>on</u> <u>something</u> and therefore the laws of such influence must differ as the object influenced differs" (Hirsch & Tryon, 1956, p. 403). Be-havorists in the past paid only token respect to heredity

and concentrated their efforts on the "more important" environmental conditions, (e.g.) "Heredity sets the limits but environment determines the extent of development within those limits" (Hirsch, 1967, p. 420). Such a statement is at once true and misleading. It truth lies in its expression of the norm-of-reaction concept. The phenotypic development of each genotype is determined by its ontogenetic environment. The misleading aspects of the statement are due to typological thinking. "Because there is no place for individual differences in the typological frame (uniformity is axiomatic), a true statement has been misconstrued as justifying the impossible, that is, the study of environmental influences per se " (Hirsch, 1967, p. 421). What appears theoretically impossible, has of course been practically feasible within limits on the assumption that the variation pattern for responding to the limitless set of conceivable environmental conditions were fairly well the same for different genotypes. The convergence of the traditional environmental emphasis with a recognition of the genetic determinants of behavior is desirable and fortunately increasingly more evident in the experimental literature.

It is useful to consider briefly the concept of emotionality or emotional reactivity. The first experiments using the open field (Hall, 1934; 1936) were concerned with examining traits of behavior called emotionality or temperament...

> "The term emotionality is defined as the state of being emotional. This state consists of a group of organic, experiential and expressive reactions and denotes a general upset or excited condition of the animal. Emotionality can be thought of as a trait since animals and men differ in the intensity of emotional reactions displayed. ... Emotionality is preferable to the term emotion since the latter implies for most psychologists that a differentiation of emotions can be made. The current point of view is that such a differentiation is extremely speculative." Hall (1934) p.385.

The term emotionality and its correlatives refers then to characteristics of behavior indicating varying degrees of reactivity, excitability or responsiveness. Early experimenters (1930's), in line with behavioristic psychology which identified emotions with visceral reactions (Carr, 1928; Dunlap, 1928; Watson, 1930), studied differences in emotionality by placing different strains of rats and mice in the open field and observing variation in elimination, a measure assumed to reflect the relative intensity of emotionality displayed by individuals. Subsequent studies have used many other behavioral correlates of autonomic functioning such as activity, latency to move and speed of movement.

More recently, there has been an increasing emphasis on concepts such as arousal and activiation. These terms primarily introduced by Malmo (1957) and Duffy (1962) differ from emotionality in the sense that arousal specifies a continuum of physiological functioning ranging from minimum (sleep or coma) to maximum (wild excitement). As an internal state, arousal can be measured by physiological indicators. The relation between arousal and emotionality can be understood if emotionality is considered as reflecting instability of level of arousal. "A more cumbersome but more accurate phrase than emotionality might be 'lability of arousal'"(MacKay, 1965). Evans and Hunt (1942) considered habituation as an important aspect of emotionality remarking that, "...emotionality appears to depend upon the rate at which the observable evidences of emotional excitation are extinguished in a strange situation" (p.541). In this sense the more emotional animal may not necessarily posses an overall higher level of arousal, but instead may be less capable of habituation from a high level of arousal to a lower level. Emotionality or emotional reactivity is used in this study in distinction from arousal. Visceral reactions and autonomic functioning such as defecation and activity are assumed dependent measures of emotionality bearing no necessary relation to physiological arousal.

Research methodology designed to investigate the effects of prior experience on subsequent emotional behavior dates from the early 1950's. Basically this research

has dealt with the question of critical periods (Scott, 1958; 1962) and was more directly concerned with the functional relationships between classes of independent and dependent variables or with stimulus input and emotional reactivity (King, 1958; Denenberg, 1964). Critical periods can probably best be studied by means of a precise examination of these parameters. However, within the context of the present study, emotionality does not only denote a functional relationship, rather it is expected that emotionality considered as an intervening variable has surplus meaning and hence greater integrating power. This is particularly relevant in interpreting the expression of its effect on the variety of measures employed in this study.

Effects due to prior stimulation

Two major hypotheses relating prior experience and later emotionality have emerged in the last two decades. Hall and Whiteman (1951), reacting against J.E. Anderson's (1948) statement contradicting the psychoanalytic emphasis on the effects of early trauma, tested the hypothesis that "subjecting the infant organism to intense stimulation will result in emotional instability in later life" (p.61). Beginning at four days of age, mice were subjected to four 2 minute periods of a loud, high frequency bell. At 30 to 40 days of age these mice and non-stimulated controls were tested in an open field situation. At 70 to 80 days of age, Stone's (1932) stovepipe test was employed, and at 100-110 days of age the open field test was repeated. On the basis

of defecation, urination and latency scores, it was concluded that animals subjected to intense stimulation during infancy were emotionally unstable in later life. That is, the experimental animals tended to defecate and urinate more, and have longer latencies than controls. However, only the first open field test measures were found to be significant, and on the stovepipe test only a small number of animals could be described as having been influenced by the early experience. These results, increased defecation and greater timidity, have been confirmed using essentially the same procedure, Lindzey, Lykken & Winston (1960). Lindzey, Winston & Manosevitz (1963) also reported a reduction in motility or activity in the open field by the experimental animals. In both these studies it is evident that the effects due to stimulation have generality, as these were observed in both the open field and the stovepipe. However there is evidence that the effects of stimulation diminishes with the passage of time as was already noted by Hall and Whiteman (1951) and particularly by Lindzey et al., (1963).

> "If we assume that the effect of the experimental treatment is to lower the threshold for aversive stimuli and further that the aversiveness of the open field undergoes adaptation or dimunition with time, it is easy to reason that the threshold differences between experimental and control Ss at

> 30 days were too pronounced to be concealed by adaptation effects. However, by 100 days the differences between the two treatment groups have decreased to a point where adaptation effects readily eliminate them ..."(p.626).

Similarly the effect of electric shock pre and post weaning, has been found to increase defecation in the open field (Henderson, 1964) and to decrease ambulation or exploration in the open field (Henderson, 1965).

This theoretical position (Hall & Whiteman, 1951) has neither specified the quality not the quantity of the independent variable and has simply stated that early or more accurately, prior intense stimulation (King 1958; Ader 1959), lowers resistance to later stress, defined as the novel situation. Operationally, traumatized (high frequency bell or electric shock) animals (mice) tend to defecate and urinate more in the open field, are less active in the open field and show greater timidity in the stove-pipe. These animals are therefore defined as more emotional than non-stimulated (non-traumatized) controls. However some other studies report no effect due to stimulation: using rats (Griffith & Stringer, 1952; Scott, 1955) and using mice (Stanley & Monkman, 1956; Henderson, 1967).

The second theoretical position was first stated by Levine (1956), who hypothesized the "early" handling constitutes a stressful situation for the infant organism,

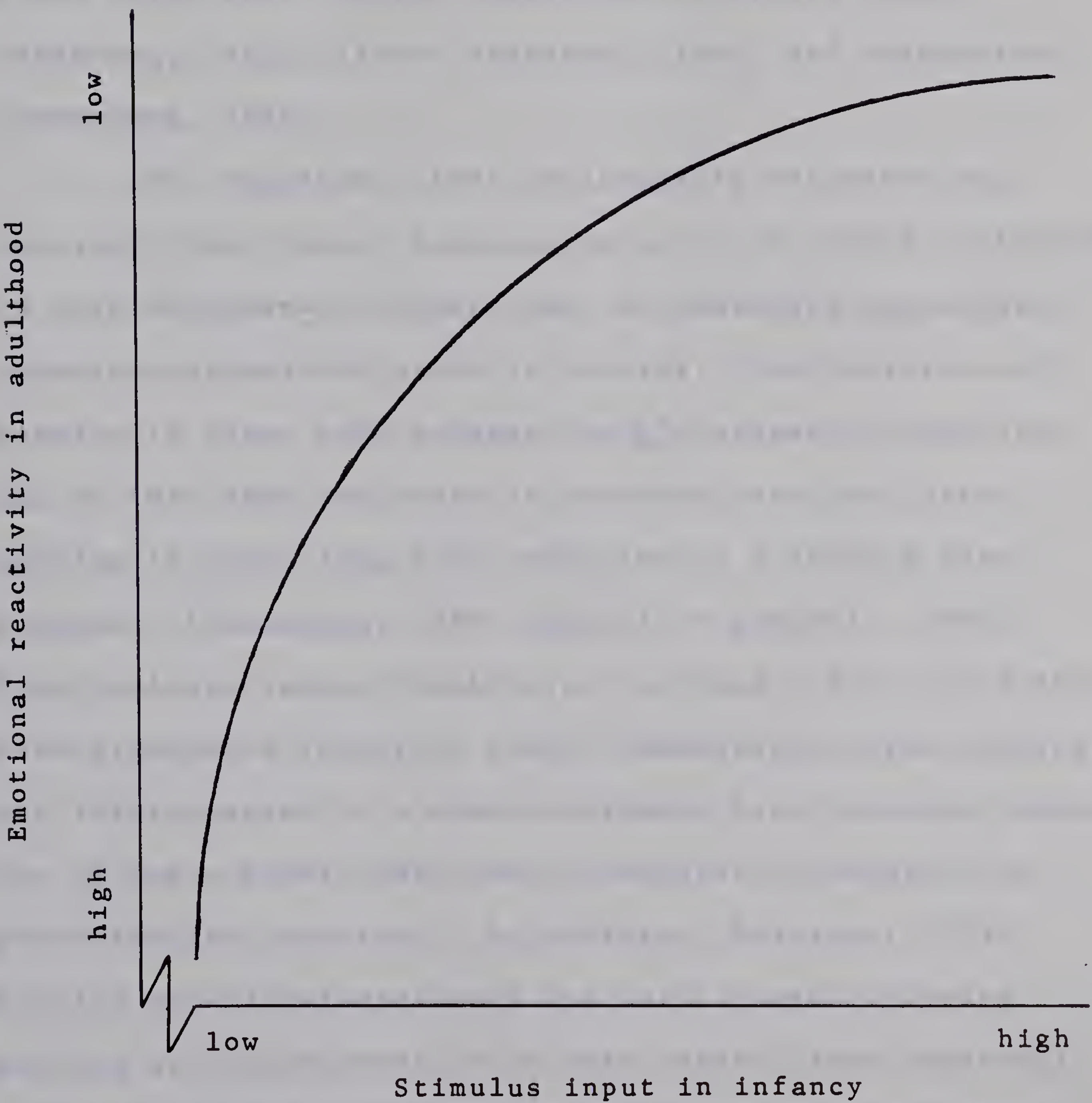
and that such early experience with "noxious" stimulation resulted in a greater ability of the organism to adapt to psychological and physiological stress as an adult. Subsequently this position has been made more explicit by Denenberg (1959) who stated that "emotional reactivity is reduced as a monotonic function of amount of stimulus input in infancy" (p. 338). This theoretical position is then the direct inverse of that proposed by Hall and Whiteman (1951). The position as stated by Denenberg (1964) directly specifies the effect of varying the quantity, duration and intensity of the stimulus input. In addition it assumes that qualitatively different methods of stimulating the organism in infancy have similar consequences in adulthood, and, on the response side, that different operational measures of emotional reactivity yield internally consistent results. In general the research supporting this position has employed handling and electric shock as methods of stimulating Ss while emotional reactivity has been measured by defecation, urination, activity, latency as well as avoidance learning (Levine, 1956; Henderson, 1964).

Denenberg, Carlson, and Stephens (1962) varied the amount of stimulus input by handling rats for 0 (control), 10 or 20 days in infancy. Open field testing in adulthood indicated the controls had the highest defecation rate while the group handled for 20 days had the lowest defecation rate. In a related study (Denenberg & Smith, 1963) one group of rats received 3 minutes of shock daily from day 11 through

day 20, a second group was placed on the unelectrified grid (handled) and a third group was non-disturbed. Both groups which received stimulation in infancy were more active than the non-disturbed group and had a lower percentage of defecation. Furthermore the shocked group was significantly less emotional (defecation measure) than the handled group. A good deal of research appears to support Denenberg's (1964) monotonicity hypothesis relating stimulus input in infancy (pre-weaning) to emotionality in adulthood. Figure 1, presents an idealized curve showing this theoretical relationship. The negatively accelerated form of this curve is suggested by the findings that the greatest change in behavior occurs between the non-disturbed group and the group receiving intermediate amount of stimulation.

It has already been suggested in the discussion concerning the concept of emotionality that its measurement is dependent at least in some part on the nature of the task. When one examines the effects of stimulus input on such measures as avoidance learning and underwater swimming, that is, tasks with some noxious element, it may be expected that the emotionality of the organism will have a significant effect upon performance in these tasks. There is probably an optimal level of emotionality for efficient performance. As one moves away from this optimal level of emotionality, performance should drop off, resulting in an inverted U function (Broadhurst, 1957; cf Hebb, 1955).

Figure 1. Theoretical curve relating stimulus input in infancy to emotionality in adulthood (Denenberg, 1964, p. 341).



Bell and Denenberg (1963) gave mice .1 ma, .3 ma, or .5 ma of shock in infancy, handled other groups and did not disturb still one other. Adult avoidance performance reveals an inverted U function where performance improved for the 0.1 ma, 0.5 ma, 0.3 ma, groups respectively over the non-disturbed treatment condition. Similar results were found using rats (Levine, Chevalier & Korchin, 1956; Denenberg, 1962; Kline & Denenberg, 1964) and using mice (Denenberg, 1959).

The hypothesis that emotionality decreases as a monotonic function of stimulus input is of course restricted to data obtained on rodents and, as Denenberg emphasizes, organisms stimulated prior to weaning. The criterion of weaning is often made because the S's senses are functioning by this time and there is evidence that only after weaning is there long-term retention of a learned fear response, (Denenberg, 1958; Campbell & Campbell, 1962). Nevertheless, Baron, Brookshire & Littman (1957) found that rats stimulated (electric shock) immediately after weaning, and later exposed to a shock-avoidance test situation where the CR was a lever press, were consistently superior to non-stimulated controls. In addition, Weininger (1956) handled rats 10 minutes each day for 21 days following weaning and found these to be more active (less emotional) in an open field situation than the non-disturbed (non-handled) animals. Similar results have been found by Ader (1957).

Particularly relevant to the study to be reported here is one by Henderson(1964). He subjected mice to electric shock or handling at age 1, 8, 15, 23, 30, 40, and 55 days. These Ss and a control group were tested in the open field at 60-61 days and in an avoidance runway at 85 days. As previously stated he found the manipulated animals (combined shock and handled groups since these were not different) with a higher mean defecation score for all ages. However, among these manipulated groups, a curvilinear trend was apparent with groups handled or shocked at 23 and 30 days of age showing higher defecation scores than groups treated earlier or later. The manipulated animals showed superior avoidance learning over all ages of stimulation compared to non-disturbed controls. Again a curvilinear trend was found among manipulated Ss with groups handled or shocked at 23 and 30 days of age showing fewer median trials to criterion than groups treated earlier or later (see figure 2). In this study as in Weininger (1956), Baron et al., (1957); Ader (1957), Brookshire et al., (1961) intense post-weaning stimulation appears to affect later emotional reactivity. The study by Henderson (1964) indicates that this effect is definitely dependent on age at stimulation.

The Henderson (1964) study clearly demonstrates that the effect of intense stimulation, electric shock, was more profound when it was presented shortly after weaning, 23-30 days. It is important for the present study that optimal parameters be used so that strain and strain by treatment

Figure 2. Defecation scores 60 - 61 days of age for Ss receiving prior treatment (Henderson, 1964, p. 285).

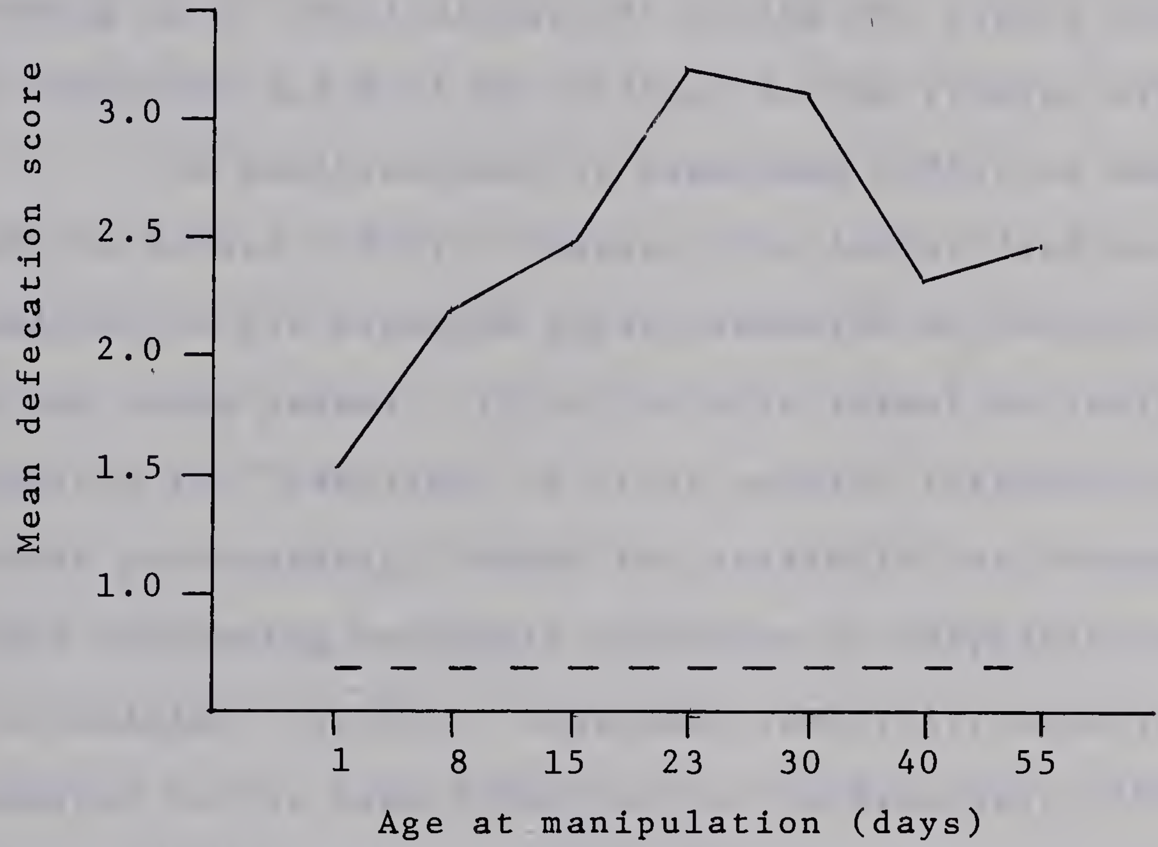
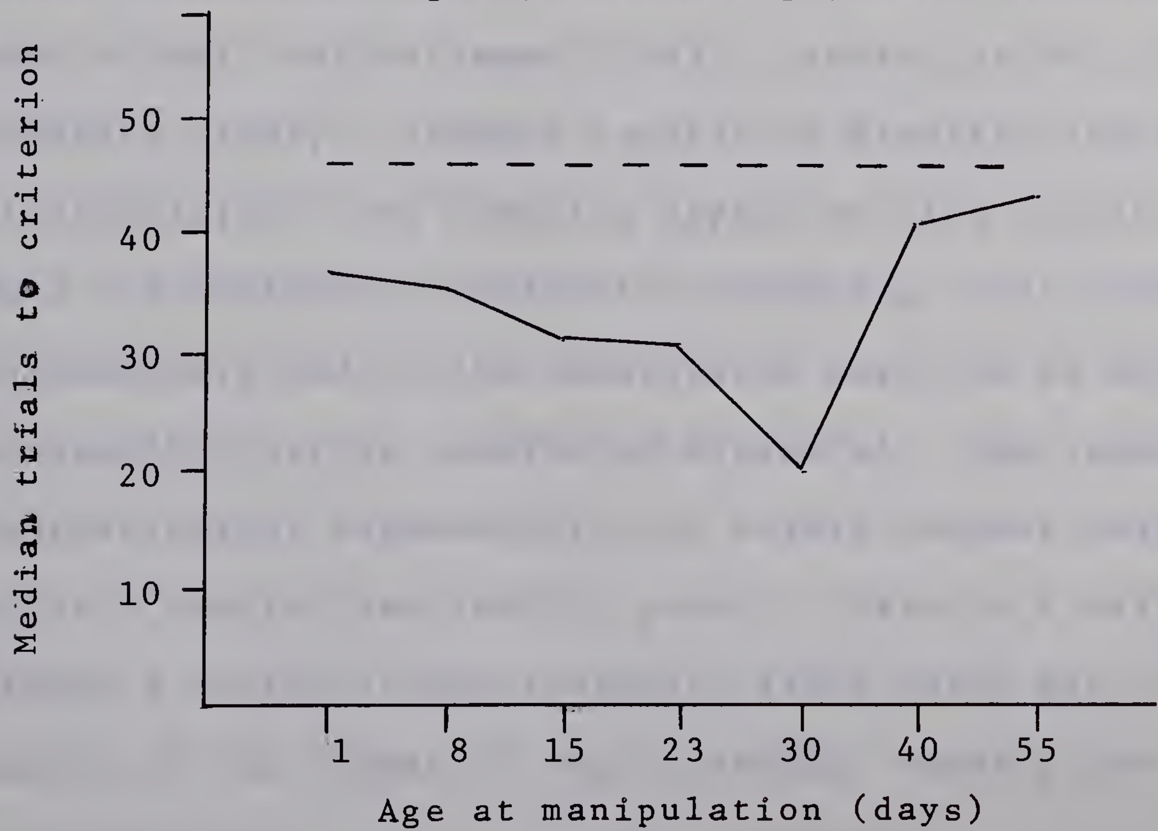


Figure 2 (a). Median trials required to reach avoidance criterion for groups receiving prior treatment (p.287).



differences can be detected. Since by manipulating age at treatment one can eliminate the effect of treatment, Henderson's finding of a "critical period" during the fourth week of life is important and will be utilized in the present study.

The position held by Denenberg (1964) is supported in part by Bovard (1958). However, the latter does not view handling on the stimulus input dimension as noxious (stressful) to the young animal. It is for this reason he posits that early handling (or "gentling" as it is usually referred to if it occurs post-weaning) raises the threshold for response to stress "thus conserving metabolic resources or adaptation energy of the organism" (p.259). Emotional reactivity measures can be expected in the same direction as the Denenberg (1959) and Levine (1956) predictions but for different reasons.

Bovard, on the other hand, believes that "early stress lowers resistance to later stress" (p.260), supporting the views of Hall and Whiteman (1951), Lindzey et al., (1960)and Henderson (1964). However insofar as electric shock (stressful stimulation) and handling appear to have similar properties vis à vis emotional reactivity (Denenberg, 1964; Ader, 1959), the Denenberg and Levine theoretical position is well supported and handling may be considered stressful. The importance of the theoretical reformulation by Bovard becomes evident in the use of a handled and control group. There is a difference between a control (non-treatment) group which has yet been handled in the course of cage cleaning, weaning and laboratory

conditions, and one which has not been handled at all except in the weaning transfer and was housed essentially in "deprived" laboratory setting. In addition, the type of handling employed, for example by Levine and Otis (1958) where the animals were simply removed and replaced in their home cage, or, by Henderson (1967) where the animals were placed on an electric grid without shock, differs considerably from the handling employed by Bovard (1958) who stroked the animals for some period of time or for some number of strokes. It is also expected that the effect of the different handling procedures would depend on the kind of animal employed as well as on the age at stimulation. The importance of Bovard's position in this context may be restricted to the methodological problems associated with quality and intensity of stimulation.

In order that the effects of environmental stimulation may be studied systematically it is desirable that stimulus input can be ranked on a continuum without making a-priori statement about the effects. Preferably the functional relationship between input and emotional reactivity should be studied by varying a stimulus quantitatively over a single dimension. One aim of this study is to follow this procedure. In the present study the non-disturbed controls are animals which have not been handled at all between birth and testing time; the "handled" (control) animals are put into shock-apparatus with the shock on but the voltage set at zero; and the two experimental groups are placed in shock apparatus at two intensities of electric shock the higher level double the

voltage of the lower level. Even though this procedure appears to present some continuum of stimulus input there is no evidence that this is so.

<u>Effects due to strain</u>

The second major concern of this study is with the effect of strain differences on emotional reactivity. The literature in this area is considerably more limited. Compelling theoretical reasoning (Falconer, 1960; Hirsch, 1967) and somewhat fragile empirical evidence (King & Eleftheriou, 1959; Lindzey et al., 1960, 1963; Winston, 1963: Levine & Broadhurst, 1963), indicate that genetic variation may influence the effect of early prior stimulation upon later emotional reactivity. King and Eleftheriou (1959), used two inbred subspecies of deermice (peromyscus) differing in wildness. Stimulation consisted of handling (by-machine) for 10 minutes a day, from day 3 to 25, and testing at 79 days of age in an activity alley and a week later in an avoidance conditioning task. The "wild" strain was more active than the "docile" strain, and the handled mice of both subspecies spent more time in the activity apparatus than the control mice. The "docile" strain performed better in the conditioning apparatus than the "wild" strain, and the handled "docile" strain performed better than their controls, while the treated "wild" strain performed less well than their controls. These inconsistent results (high emotionality has been defined as low activity and poor learning performance with the inverse for low emotionality) are more comprehensible if, as King &

Eleftheriou suggest, high activity is interpreted as "escape" behavior and associated with poor learning performance. These authors view their findings as consistent with Levine's (1956) hypothesis that handling enables the animals to adapt to later stress on "the basis that the innate capacities of each subspecies determine their method of adaptation to handling; one subspecies (wild) adapts by becoming more emotional while the other subspecies (docile) adapts by becoming less emotional" (p.87).

Levine and Broadhurst (1963) used two strains of laboratory rats, bi-directionally selected for high and low emotional defecation as measured in the open field test. Stimulation consisted in handling (3 minutes a day in a cardboard box) from 1-21 days. Testing in open field and avoidance conditioning began at 106 days of age. In the "low emotional" strain there was little effect evident due to stimulation as measured by open field defecation and avoidance learning, whereas, in the "emotionally reactive" strain handling reduced defecation in the open field but also decreased avoidance performance. As Levine & Broadhurst (1963) state..."this further decrease in avoidance learning which occurs as a function of infantile stimulation in the reactive strain does not fit any currently held concept of the effects of infantile manipulation on avoidance learning" (p. 427). Nor can this result be reinterpreted as in King and Eleftheriou (1959) study, since a decrease in defecation appears a fairly well established index of reduced emotional reactivity.

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The studies quoted earlier by Lindzey et al.,(1963; 1960) examined the effects of manipulation ("trauma") in four inbred strains of mice and found defecation and motility differences in the open field at 30 and 100 days of age and latency differences in the stovepipe test at 70 days of age. They concluded: "There seems little doubt that genetic factors contribute importantly to the level of emotionality, timidity and motility as measured in our study. In addition, it appears that at least some influence is exerted by genetic factors upon the rate of adaptation to a fearful situation" (Lindzey et al., 1963, p. 627). These authors also observed strain by treatment effects or genetic-ontogenetic interactions. Nevertheless such findings are not conclusive as strain differences even in a well controlled environment may be due to prenatal and postnatal maternal effects and cytoplasmic inheritance (Broadhurst, 1967). A crucial question with respect to genetic differences concerns the behavioral consistency on measures of emotionality of the various strains in their responsiveness to prior manipulation. One manner to test for such consistency is to use several strains, to apply constant treatment in a uniform environment, and to use multiple dependent measures. It is then possible that for a particular genotype, the genetic-ontogenetic interaction can manifest itself in connection with a particular dependent measure, while for another genotype, the genetic-ontogenetic interaction may be detected only in connection with another dependent measure. However, when several behavioral measures

are taken the possibility exists that order or sequence effects will influence the measures.

A particular conceptual problem which has already been alluded to concerns the purity of the construct "emotionality." Inconsistencies on dependent measures have been attributed to the kind of organism employed, to the stimulus parameters, and to the nature of the dependent variables. Nevertheless it is possible that "high activity" may be interpreted both as "exploration" or as "escape behavior". In the former the animal would be designated "low emotional" while in the latter as "high emotional". Although it is possible that the different dependent tasks are not all measuring emotionality it is also possible that emotionality is a factorially complex construct. Whimbey and Denenberg (1967) found that open field activity has two factors namely "emotional reactivity" and "exploration". Furthermore they found that high activity on the first day of open field testing was indicative of high emotionality whereas high activity from day 2 onward was indicative of low emotionality. Such complexity would appear to make it desirable to repeat measures over days (Salama & Hunt, 1960), as well as to use a number of dependent measures so that consistency may be sought among these. Factor analytic studies of animal behavior (Royce, 1955; Willingham, 1956; Furchtgott & Cureton, 1964 and Royce et al., 1969) have indicated that emotionality cannot be regarded as a single behavioral dimension. Without going into factor analysis in this study, an attempt to examine

the complexity of emotionality has been made by using six behavioral tasks which are putative measures of emotionality in mice (Royce et al., 1969).

The present study makes use of two highly inbred strains of mice bidirectionally selected for high and low emotional reactivity (Royce, Carran & Howarth,1969). Particular care was taken to ensure a uniform environment. At 23 days of age these animals were subjected to three levels of stimulation, 0 and two levels of shock, for two days, while a control group was not disturbed. At 50 days of age all animals were tested on a series of dependent measures. This design enabled a test of Denenberg's (1964) hypothesis namely that emotional reactivity is reduced as a monotonic function of the amount of stimulation in infancy. The fact that a variety of dependent tasks were employed and the measures were repeated over time allowed some examination of the generality of the manipulation effects. The use of two inbred strains, the environmental control, and the use of several dependent measures allowed some inference about the genetic effect and the genetic-ontogenetic interaction.

On the basis of current evidence it was expected that environmental stress would have its greatest effect on the "high-emotional" strain. It was expected that the effect of prior manipulation would be most evident between the two shock groups and the control group (Bovard, 1958). As prior manipulation becomes more intense, emotional reactivity should increase, as predicted by Hall and Whiteman (1951); Lindzey

et al., (1960). Operationally it is expected that the measures of defecation, urination and latency will increase and the measures of activity will decrease. For the "low emotional" strain the effects should follow the predictions made by Denenberg (1964). As prior manipulation becomes more intense, emotional reactivity is reduced. Operationally it is expected that the measures of defecation, urination and latency will decrease and the measures of activity will increase. Under all treatment conditions it is expected that the "low emotional" strain should have lower measures of defecation, urination, latency and higher measures of activity than the "high emotional" strain. Therefore it is expected that the "low emotional" strain will adapt to prior manipulation by becoming less emotional and the "high emotional" strain will adapt by becoming more emotional. This differential effect due to prior manipulation and dependent upon strain is expected to vary somewhat with the nature of the dependent task, yet within the limits of the above expectations.

Method

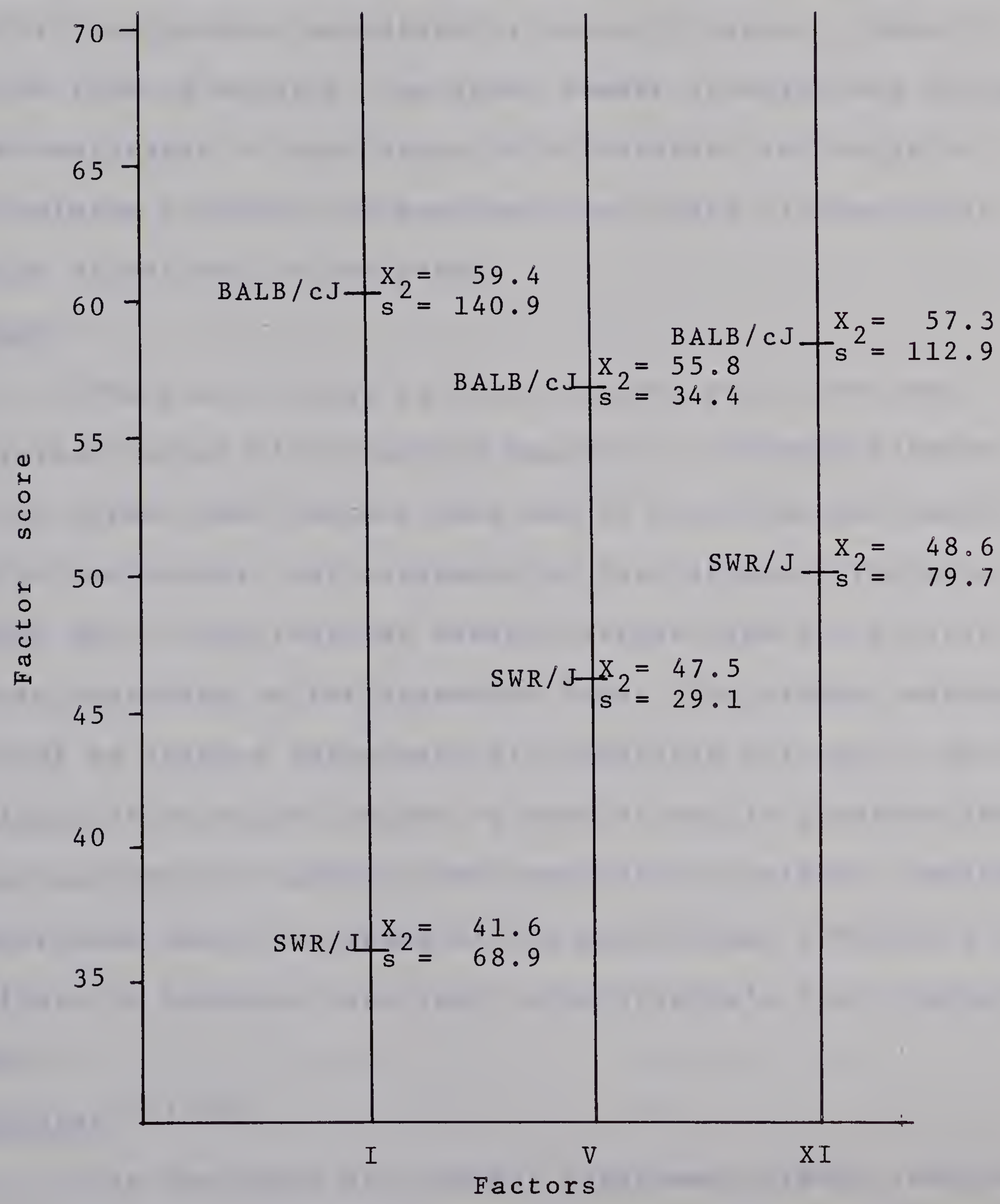
A primary methodological objective was to obtain animals with a stable genetic background, born and maintained under uniform environmental conditions. This was accomplished by breeding all animals in our own laboratory, under strict environmental controls, using inbred parental stock obtained from the Jackson Laboratory. Breeding pairs were either of the SWR/J or BALB/cJ inbred strains, no more than 10 generations removed from a common ancestral pair. The common ancestral parents were the product of more than 20 generations of brother-sister matings (100 in the case of BALB/cJ and 92 in the case of SWR/J according to the Jackson Laboratory Handbook, 1968). All animals were born and maintained under controlled laboratory conditions consisting of a 12 hour night-day cycle, a temperature of 74 ± 1 degree fahrenheit and a relative humidity of 55 percent. The breeding room and laboratory were soundproof and relatively dustfree.

A second methodological consideration was the choice of stimulation and the age at stimulation. In view of the experimental literature (Beach & Jaynes, 1954; King, 1958; Denenberg, 1964) it was decided to use exposure to unavoidable electric shock to produce differences in emotionality. This procedure was sufficiently different from any of the test measures, and ensured a constant and uniform stimulus input that could be varied systematically over a single dimension. Only two of the four experimental groups within each strain were subjected to electric shock stimulation.

A "control" group was put on the grid however the voltage level was set at 0, and another "non-disturb" group received no stimulation whatever and was maintained under laboratory conditions until time of testing. The voltage level for the two shock conditions was determined on the basis of pilot work. The lower level was the voltage required to cause jumping and squeaking of the weanlings (35 volts) while the higher level was set at double the voltage of the lower level (70 volts). The lower level voltage was sufficient to ensure constant arousal and the higher voltage level was well below the lethal limit. The duration of treatment for the two shock and control groups was set at 3 continuous minutes per day, for two days (Henderson, 1964). Thus experimental rather than theoretical considerations governed the choice of voltage levels and the duration of treatment.

Finally, the choice of the strains and of the dependent measures employed was based upon a factor analytic study of emotionality using inbred strains of mice. In this study (Royce, Carran, & Howarth 1969), SWR/J and BALB/cJ mice were found to be two divergent strains, differing significantly on three factors (see Table 1). The BALB/cJ strain was found to be the more emotionally reactive strain. The dependent measures that have loadings of .30 or higher on these three factors comprise the battery of dependent tasks used in this study. The order of presentation of these tasks and the age at testing follows from consideration of the same research (Royce et al., 1969). The two strains, SWR/J and BALB/cJ

Table 1. Factor means and variances for the BALB/cJ and the SWR/J strain (n = 11). 7th oblique rotation. Royce, Carran & Howarth (1966)



have also been found to be divergent in avoidance conditioning performance (Royce & Covington, 1960).

Subjects

A total of 80 mice were used as subjects derived equally from two inbred strains, SWR/J and BALB/cJ. Pups of each litter, of both strains, were sexed and designated to one of four groups, non-disturb, control, shock 1, shock 2, at the time of weaning. An equal number of males and females were designated to each group which totalled ten subjects. All animals survived the experiment and were of comparable weight at the end of the study.

Design

The basic design in this research was a four-way factorial design with repeated measures. The main effects of the three fixed factors were due to strain at two levels, sex at two levels, and treatment at four levels. The main effect due to the repeated measure varied from two to five levels depending on the dependent task. The design contained a total of sixteen cells with five subjects per cell. An analysis of variance was run on each of the 24 measures that comprised the six tasks in the emotionality battery. Multiple comparisons among the means of the significant effects of the analysis of variance were done using Scheffe's test (Edwards, 1960).

Apparatus (1) (2)

The two shock and control treatment animals received stimulation in a modified version of the avoidance conditioning

apparatus. The shuttle box was reduced in size (7 long x 3 1/2 wide x 1 5/8 high)" with the sides constructed of transparent plexiglass and the hinged lid constructed of opaque plexiglass. The shock source was a matched impedance circuit consisting of a 800-V ac transformer,(220-k ohm resistor) and a Lehigh Valley 1311 SS shock scrambler. The animals were removed by hand from the laboratory cage and individually placed in the shock box for 3 minutes at the various voltage levels of 0, 35, 70 volts for the control, shock 1 and shock 2 treatment groups respectively.

The tests that comprise the emotionality battery are described in the order these were employed.

Open field

The open field used consisted of a flat white masonite circle, 4 feet in diameter and bounded by a 12 inch flat white sheet metal wall. The field was divided into four annuli by scribing circles with diameters of 34 inches, 20 inches, and 6 inches, using .4 centimeters flat black lines. The two peripheral annuli were divided into 16 equal portions. The next annulus was divided into eight equal portions leaving a 6 inch diameter circle in the center of the field which was left undivided. The lines dividing a particular annulus ajoined the midpoints of lines of portions comprising neighbouring annuli. The flat surface of the field was covered with a transparent plexiglass sheet. The entire field was housed in a structure of 3/8 inch plywood, 64 inches long x 52 inches wide x 60 inches high with a one way glass window

17 1/4 inches x 14 1/4 inches on one side, and a door on the adjacent side for entry. A transparent plexiglass starting box 4 1/4 inches long x 1 3/4 inches wide x 2 1/4 inches high with a sliding bottom, could be raised and lowered from the outermost region of the field by means of a cord led through the wall and guided by a steel bracket located 46 inches above the field. From the ceiling of the housing, a bank of fluorescent lamps behind translucent paper provided uniform illumination of 130 foot candles as recorded by a Weston Illumination Meter. Prior to each animal run, the plexiglass surface was washed with water containing R2L disinfectant and allowed to dry. The S was then removed from its home cage and placed in the portable starting box. The starting box was then lowered into the outer annulus of the field and its sliding bottom removed. The E left the housing and closed the door. From the front of the housing, before the one-way window, the starting box was raised by means of the cord and at the same time a stop watch and a switch attached to a Gra-Lab timer were started. When the S had placed four paws in the next delineated portion of the field the timer was stopped. During a two minute time period, as recorded by a stop watch, the number of sections transversed by S were counted. At the end of two minutes the S was returned to its home cage. The following measures were recorded: (a) latency to leave starting section in seconds, (b) sections traversed (activity), (c) number of boli of

defecation, (d) presence or absence of urination, (e) penetration into field, i.e. annuli crossed.

Straighaway

The straightaway consisted of a runway 50 inches long and 1.5 inches wide elevated 31 inches from the floor. The runway was divided by .125 inch black stripes into 11 interior sections each 3.75 inches long and two 2.875 inch sections at either end. Covering the runway was a transparent plexiglass strip 1/8 inch thick which was in turn covered with transparent wire mesh of 1/16 inch squares. The straightaway was housed in a structure of 3/8 inch plywood, 62 inches long x 14 inches wide x 56 inches high with a large door and an oneway glass window 35 inches long x 2 1/2 inches wide in front for observation. A smaller hinged door was located in the front of center of the housing, just above the level of the straightaway, so that the S could easily be placed on the center division of the straightaway. Lighting was by pink fluorescent lights behind opal glass providing uniform illumination at the surface of straightaway of 20 foot candles. Prior to each animal run, the plexiglass surface and wire mesh was washed in water containing R2L disinfectant and allowed to dry. The S was removed from home cage and placed in a portable plexiglass starting box 4 1/4 inches long x 1 3/4 inches wide x 2 1/4 inches high having a sliding bottom. The box was placed in the center of runway and sliding bottom removed. The plexiglass box was then removed, and a stop watch and a

switch attached to a Gra-Lab timer were started. When S placed all four paws in the next delineated section the timer was stopped. During the next three minutes the number of sections traversed were counted according to the criterion. The following measures were recorded: (a) latency to leave starting section in seconds, (b) sections traversed (activity), (c) number of boli of defecation, (d) presence or absence of urination.

Stovepipe

The pipe apparatus consisted of two white opaque goal boxes 6 1/4 inches square x 4 inches deep connected by a gray plastic tube 24 inches long with a 2 1/8 inch inside diameter. Each goal box had a hinged transparent lid perforated with airholes. On one side of each goal box a circular opening covered by a sliding opaque door led into the pipe. The apparatus was housed in a 3/8 inch plywood structure 30 inches wide x 43 inches long x 22 inches high with a hinged door at the front and a 5 inch square one-way window mounted on top near each end. Cords connected to the sliding doors of the goal boxes led through the housing nine inches from each end. Uniform illumination was provided at 20 foot candles by a bank of pink fluorescent lights behind opal glass. The apparatus was washed with R2L prior to each animal run. At the end of a 14 hour food deprivation period the S was removed from home cage, placed in the right goal box, and allowed two minutes adaptation. A 5 milligram food pellet was placed

in the other goal box. When the S "faced" the sliding door it was opened and a Gra-Lab timer started. This timer was stopped, which automatically started another timer, when S entered the pipe with all four paws. The starting box was closed and the goal box opened. The second timer was stopped when S emerged from the pipe with all four feet. The S was allowed to consume the food pellet. This procedure was then repeated in the opposite direction. The following measures were recorded: (a) latency to enter pipe in seconds, (b) latency to emerge from pipe in seconds, (c) number of boli of defecation, (d) presence or absence of urination. These measures were again recorded on trial 2.

Activity Wheel

The activity wheels were especially constructed by Acme Metal Products, Inc., Chicago. An aluminum drum, 6 inches in diameter with a 2 inch wide band perforated with .125 inch holes and weighing 140 grams, acted as the running area. The unit had a living cage, 4 1/2 inches long x 3 inches wide x 3 inches high with an externally attached water bottle and allowed free access to the wheel. Revolutions in either direction activated a cumulative counter. The units were placed on sawdust in the colony room. Subjects remained in the units for two full days. Total revolutions were recorded from 5:30 p.m. to 9:30 a.m. (night), from 9:30 a.m. to 5:30 p.m. (day), for two days. A total of five readings including the initial reading constituted two night

and two day measures. The unit was checked each reading to see if it was functioning properly.

Avoidance Conditioning

The avoidance conditioning apparatus used has been described more fully elsewhere (Yeudall, Royce & De Leeuw, 1968). In summary it consisted of a shuttle box 3 1/2 inches wide x 1 5/8 inches high x 15 1/2 inches long which was mounted inside an insulated chamber 13 inches wide x 12 inches high x 21 inches long with a one-way window in the door located on front side of the chamber. Three photo-electric cells with infrared filters were mounted in such a way as to focus across the midline of the shuttle box. One speaker was located at each end of the shuttle box. The chamber was illuminated by a 6 watt fluorescent light and was ventilated by a small fan. The control unit was located in an adjacent room and allowed for durations of the CS, UCS, CS-UCS interval and the intertrial interval. The grid was wired in such a way that shock could be elicited on either side of the center of the shuttlebox. In this study the CS was set at 3 seconds, UCS at 3.5 seconds, inter-trial interval at 120 seconds and CS intensity at 400 volts. Intertrial activity was recorded when the animal broke the photocell beam in center of shuttlebox. A total of 25 trials per day for three days were presented. The day prior to running, the animals were given 5 minutes adaptation in the shuttlebox. Prior to the first experimental session each animal was given 5 trials of CS alone and 5 trials of UCS

alone in that order. Immediately following this pre-conditioning phase, conditioning itself commenced with 25 trials of CS-UCS presentations. If S ran to the other side of shuttlebox during the 3 second CS period the CS was terminated and a correct avoidance trial was recorded. If the S failed to make an avoidance response during this 3 second CS period a 3.5 second shock presentation signalled an error. Even if the S made a correct avoidance response during the CS period it was possible for him to make an error on that trial by immediately running back into shock.

These parameters were found to be optimal by Royce (1966a). Two measures were taken from this apparatus: (a) correct number of avoidance responses out of a possible 25 per day, (b) intertrial activity per session.

Underwater Swimming

This apparatus consisted of a clear plastic tank with inside dimensions 24 inches long x 2.5 inches wide x 4 inches high and an opaque plastic surface placed just below the water line to prevent S from rising to the surface. An automatic starting cage 2 inches long x 2.5 inches wide x 3 inches high with a guillotine door and a 55° sloping landing platform occupied the first and last 6 inches respectively of the swimway. Photo-electric relays which stopped Stoelting timers were mounted at the starting cage, 12 inches and 24 inches from the starting cage respectively. The S was placed in the starting cage, and the cage submerged when S faced the swim way, which, automatically opened the

guillotine door and started the timers. Water temperature was maintained at room temperature. Three measures were recorded; (a) latency to leave starting cage, (b) time required to cross second photocell relay, (c) time required to cross third photocell relay. Latencies were recorded in seconds to two decimal places. After a trial the S was returned to its home cage and permitted to dry before its next trial. A total of five trials were given about 15 minutes apart. The experiment took place in an essentially dark room.

Procedure

Breeding pairs were housed in translucent plastic nesting boxes 7 1/4 inches wide x 7 1/4 inches deep x 11 inches long with ad lib food and water and with shavings and sawdust. The males were removed between 9 to 18 days after pairing. The nesting cages where then cleaned and again when the pups were fourteen days of age. Time of birth was set on the day that the litter was first observed with observations being made twice a day. All animals were weaned, sexed, and placed individually in wire cages, 8 inches long x 4 inches wide x 4 inches high, on laboratory racks at 21 days of age. Rubber tipped tweasers were used in the weaning process. Stimulation of the control and two shock treatment groups started a day after weaning for two days (days 23, 24). Duration of stimulation was measured by a standard stop watch. At 50 days of age testing began and continued for 10 days. All measures were taken, except

for the activity wheel measure, in the presence of white noise. The white noise speaker with an intensity of 85 db was set at a distance of approximately 30 inches from the apparatus. The open field and straightaway were presented on the same day at 9:30 a.m. and 5:30 p.m. respectively for two days. The pipe was given at 9:30 a.m., following 14 hours of food deprivation, for two days. The activity wheel began at 5:30 on the last day of pipe and continued for two days. Adaptation for avoidance conditioning began on the last day of the activity measure and avoidance conditioning proper continued for three days. On the next day the animals were put through underwater swimming, thereby completing ten days of testing. Immediately after underwater swimming all animals were weighed and destroyed.

Footnotes

(1) All apparatus was provided and developed by the laboratory of Dr. J.R. Royce, through Canadian Public Health Research Grant DPH 33, 608-7-82 and a National Research Council of Canada Grant APT-105.

(2) A recent paper by Royce, Carran, and Howarth (1969) was of considerable assistance in descriving the apparatus. A more complete description of apparatus may be found in that paper. However, a number of subsequent changes are recorded in this study.

Results

Open field activity

A summary of the analysis of variance of open field activity is presented in Table 2. The significant main effects due to strain and treatment are not independent and their significant interaction is graphically presented in Figure 3. It is evident from this graph that the activity of the SWR/J strain is greater than the activity of the BALB/cJ strain. The between strain comparisons under particular treatment conditions indicate significant* strain differences under the control, shock 1 and shock 2 treatment conditions, however there is no strain effect under the non-disturb treatment condition.

The within SWR/J strain comparisons among treatment groups indicate that the shock 2 treatment group is significantly more active than the other treatment groups and the shock 1 treatment group is significantly more active than the non-disturb treatment group. The within BALB/cJ strain comparisons among treatment groups indicate that only the non-disturb treatment group is significantly more active than the control treatment group.

Multiple comparisons among the means of the significant strain by day and treatment by day interactions were not significant. Examination of the non-significant strain by treatment by day interaction indicates that activity in the open field on day two follows fairly closely activity recorded on day one for both strains and under all treatment conditions.

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* significant refers to statistically significant effects $p < .05$

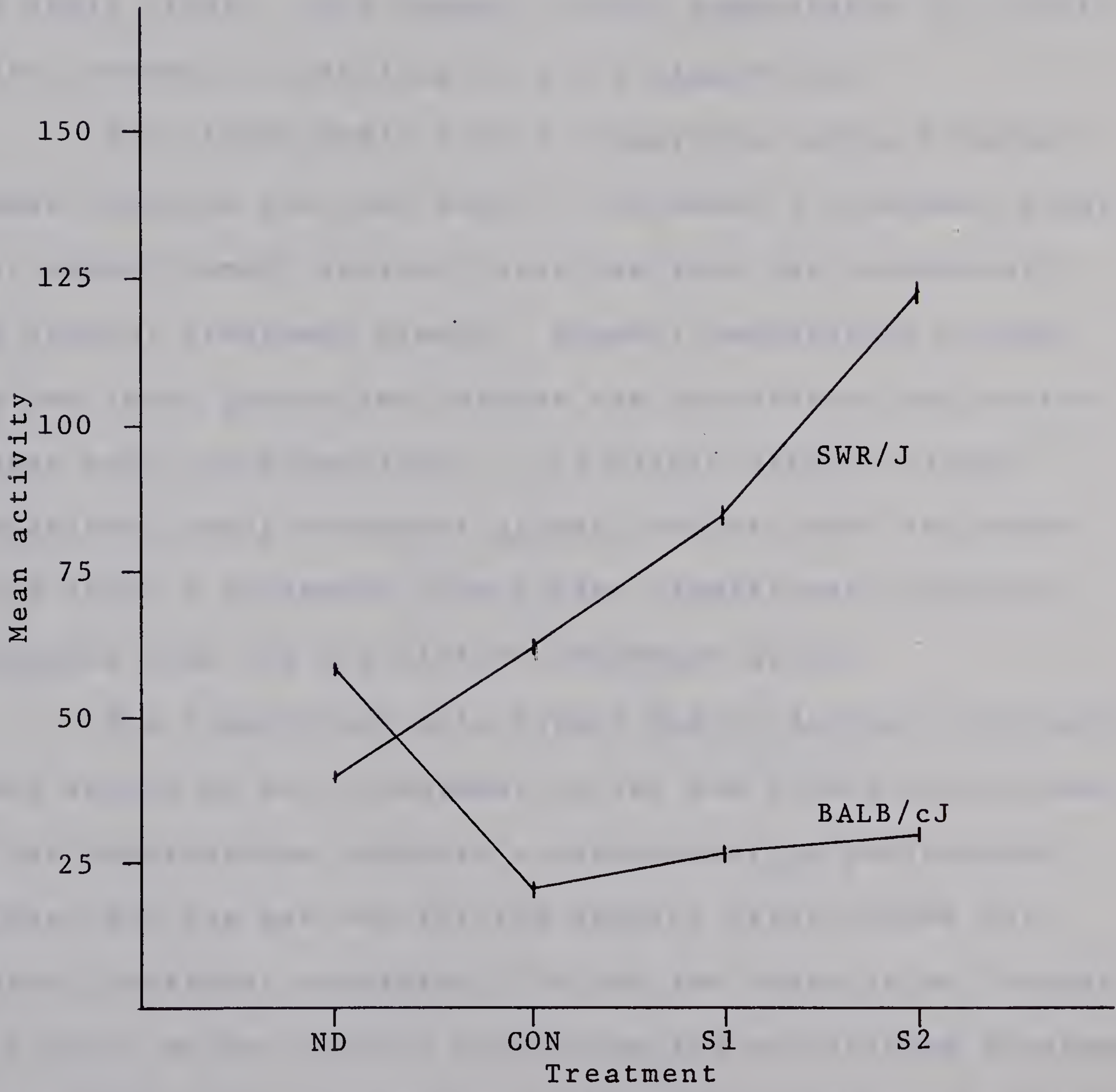
Table 2. Summary of F values of the analysis of variance of measures in the open field.

	df	F Activity	F Latency	F Defecation	F Penetration	F Urination
A (strain)	1	282.96*	11.15*	219.95*	70.18*	2.23
B (sex)	1	.85	.41	20.16*	.90	2.70
A X B	1	.12	.06	15.56*	.36	.20
C (treatments)	3	86.27*	50.67*	7.72*	23.39*	.49
A X C	3	69.62*	5.39*	25.49*	7.84*	1.35
B X C	3	.35	.27	.66	.43	.04
A X B X C	3	1.32	.88	1.10	.08	.72
S (error)	64					
R (day)	1	1.13	56.14*	.33	16.76*	.13
A X R	1	12.16*	108.23*	.90	14.36*	3.38
B X R	1	1.95	.56	.04	1.12	.54
A X B X R	1	2.39	1.49	.91	.02	.54
C X R	3	5.73*	24.18*	2.55	17.74*	1.31
A X C X R	3	2.47	23.85*	1.39	18.66*	.76
A X B X R	3	1.02	.94	.72	.63	.09
A X B X C X R	3	.19	.77	.42	2.59	.27
Error	64					
Total	159					

* $p < .01$

** $p < .05$

Figure 3. Graphic presentation of strain x treatment interaction of activity in the open field.



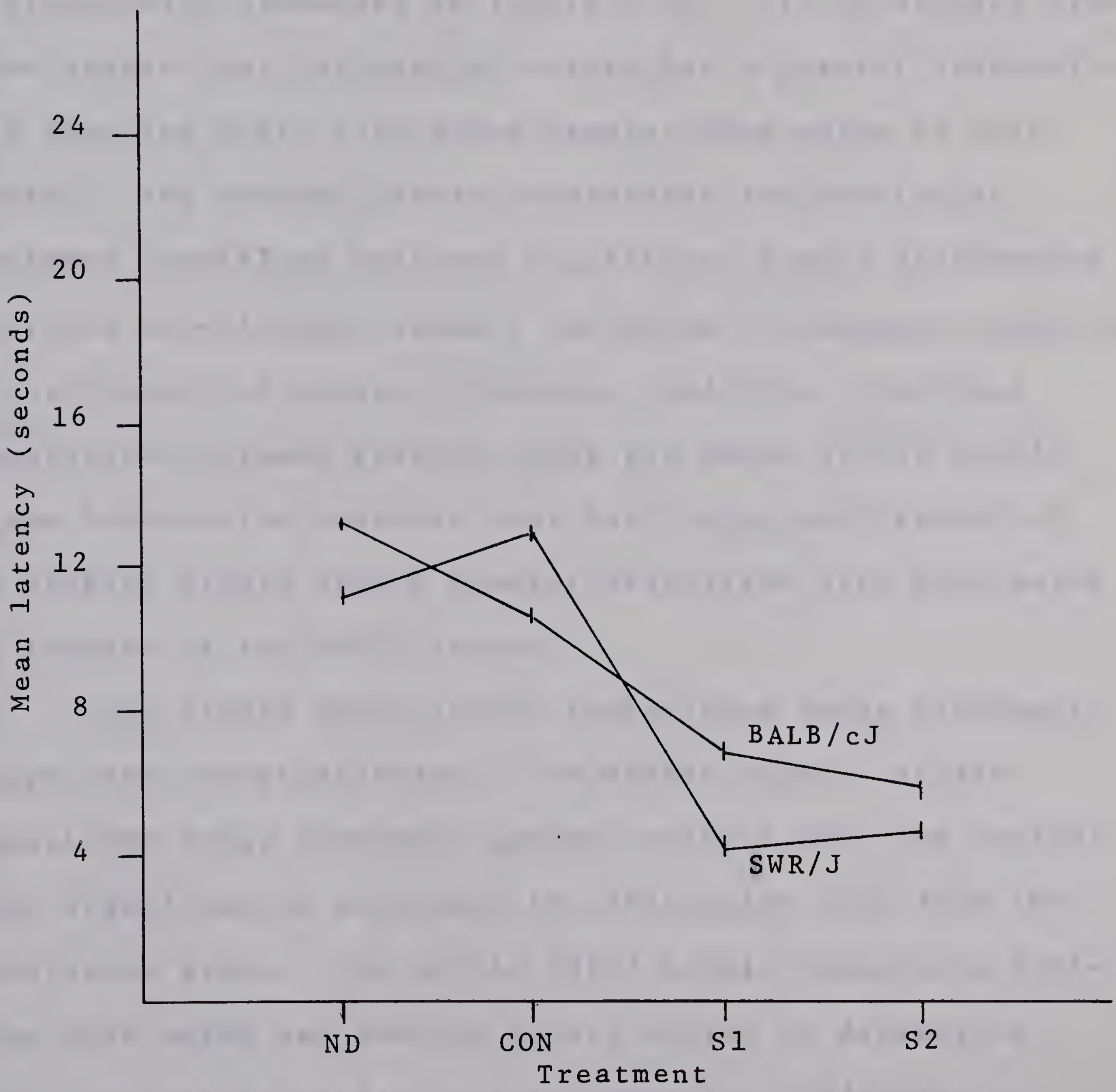
Open field latency

A summary of the analysis of variance of open field latency is presented in Table 2. The significant main effects due to strain and treatment are not independent and their significant interaction is graphically presented in Figure 4. It is evident from this graph that the latency to move in the open field is longer for the BALB/cJ strain than for the SWR/J strain. The between strain comparisons for particular treatment conditions were not significant.

The within SWR/J strain comparisons among treatment groups indicate that the shock 1 and shock 2 treatment groups have significantly shorter latencies than the non-disturb and control treatment groups. However comparisons between the two shock groups and between the non-disturb and control groups were non-significant. The within BALB/cJ strain comparisons among treatment groups indicate that the shock 1 and shock 2 treatment groups have significantly shorter latencies than the non-disturb treatment group.

The significant main effect due to day and the significant strain by day, treatment by day and strain by treatment by day interactions indicate a discrepancy in performance between day one and two for the BALB/cJ strain under the control treatment condition. On day two there is an increase in latency by the control group from the non-disturb treatment group rather than a decrease in latency as indicated on day one. Multiple comparisons among the means of these interactions were non-significant.

Figure 4. Graphic presentation of strain x treatment interaction of latency to move in the open field.



Open field defecation

A summary of the analysis of variance of open field defecation is presented in Table 2. The significant main effects due to strain and treatment are not independent and their significant interaction is graphically presented in Figure 5 (a). The significant main effects due to strain and sex are not independent and their significant interaction is graphically presented in Figure 5 (b). It is evident from these graphs that the BALB/cJ strain has a greater defecation rate than the SWR/J strain and females than males of both strains. The between strain comparisons for particular treatment conditions indicate significant strain differences under the non-disturb, shock 1 and shock 2 treatment conditions, but not under the control treatment condition. Multiple comparisions between strains among the means of the strain by sex interaction indicate that both males and females of the BALB/cJ strain have a greater defecation rate than males and females of the SWR/J strain.

The within SWR/J strain comparisons among treatment groups were non-significant. The within BALB/cJ strain comparisons among treatment groups indicate that the control group significantly decreases its defecation rate from the non-disturb group. The within SWR/J strain comparison indicates that males and females do not differ in defecation rate. The within BALB/cJ strain comparison indicates a significantly greater defecation rate for females than males.

There are no differences in defecation rates between day one and day two.

Figure 5 (a). Graphic presentation of strain x treatment interaction of defecation in the open field.

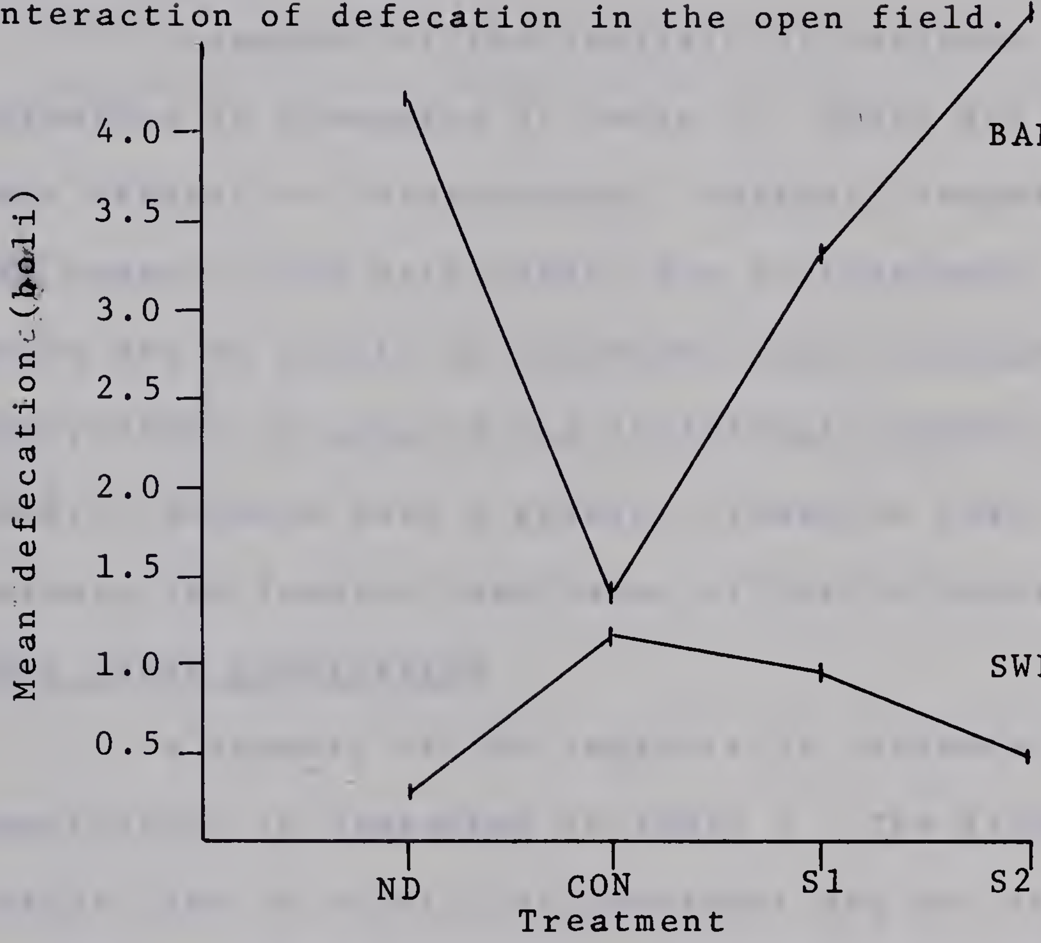
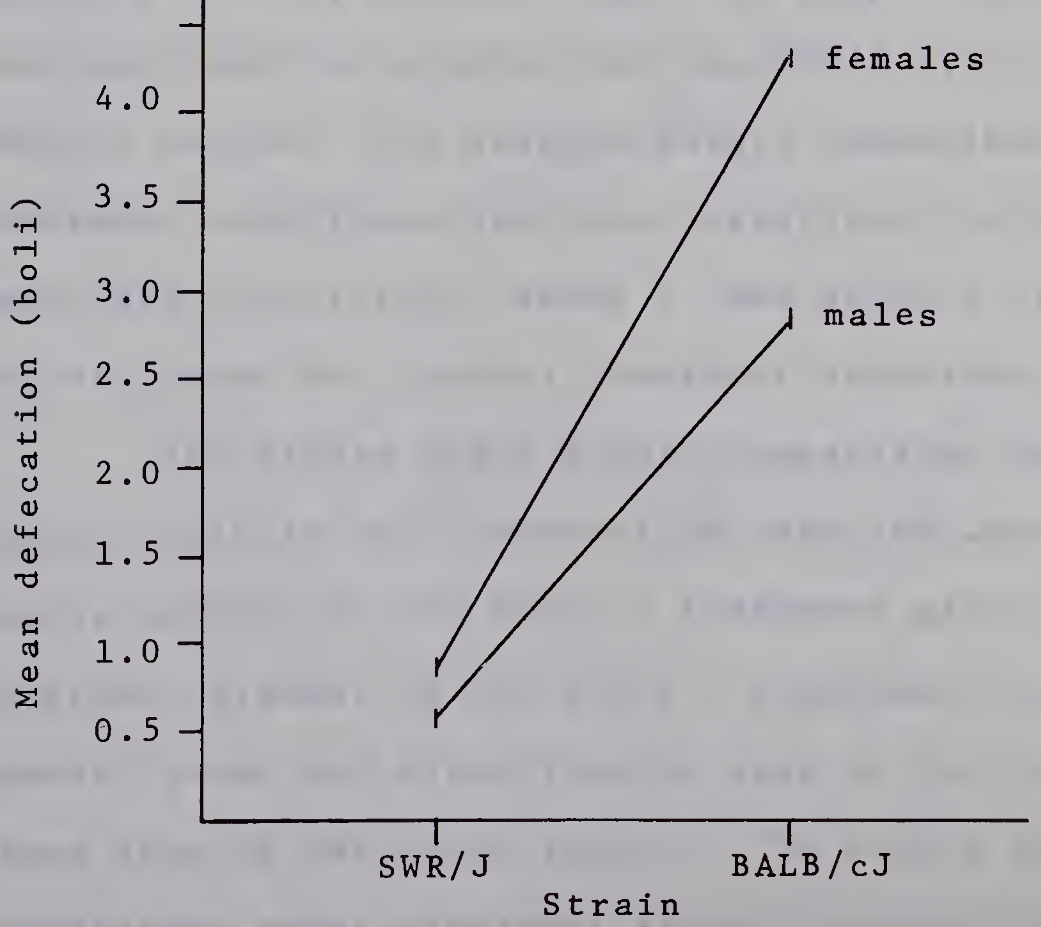


Figure 5 (b). Graphic presentation of strain x sex interaction of defecation in the open field.



Open field urination

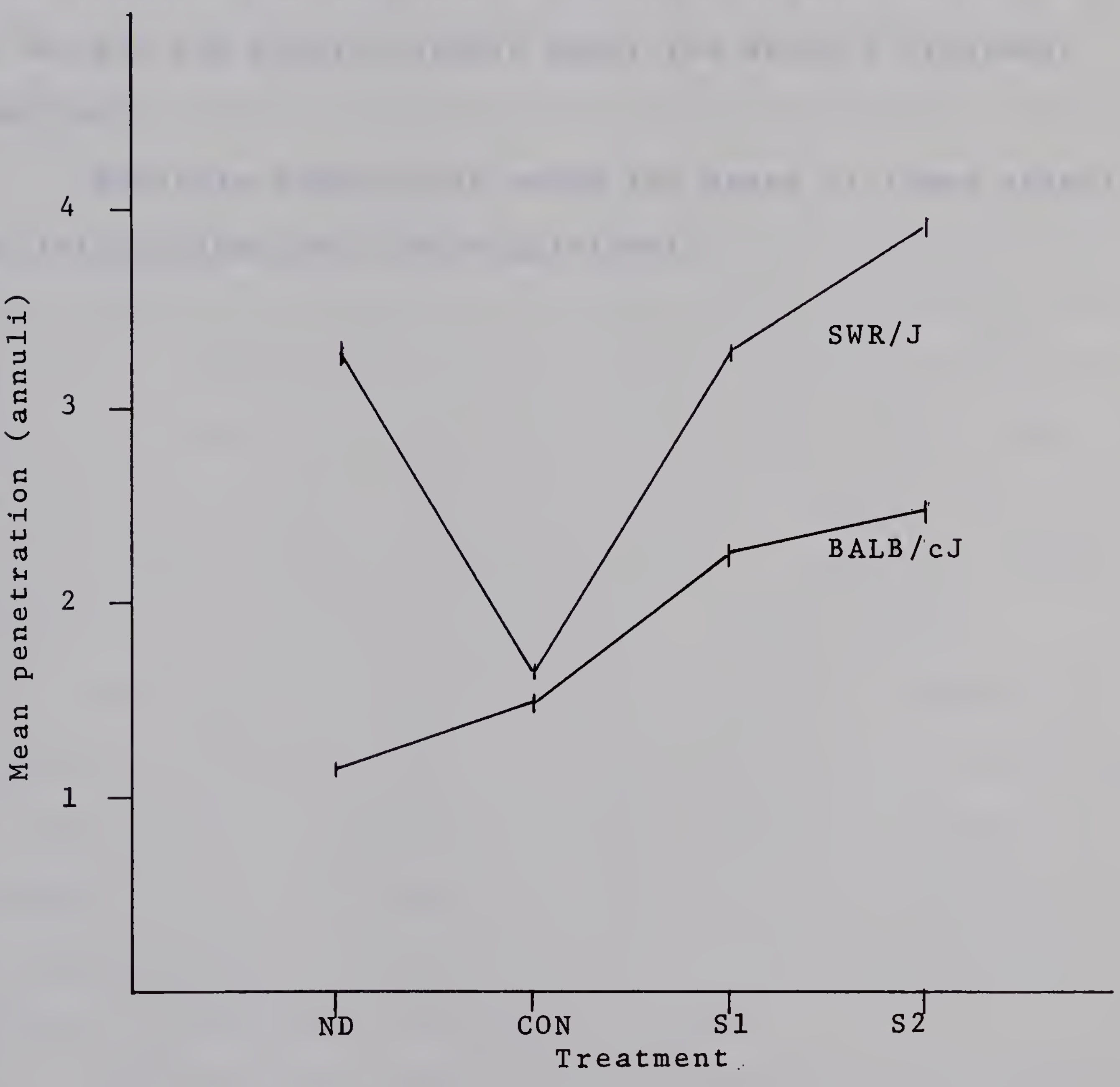
A summary of the analysis of variance of open field urination is presented in Table 2. There are no significant main effects or interactions. Multiple comparisons among the means of the main effect due to treatment and the interaction due to strain by treatment were non-significant. Observation of data of the individual subjects indicates the BALB/cJ animals have a greater urination rate than the SWR/J animals and females than males of both strains.

Open field penetration

A summary of the analysis of variance of open field penetration is presented in Table 2. The significant main effects due to strain and treatment are not independent and their significant interaction is graphically presented in Figure 6. It is evident from this graph that penetration into the open field is greater for the SWR/J strain than for the BALB/cJ strain. The between strain comparisons for particular treatment conditions indicate significant strain differences under the non-disturb, shock 1, and shock 2 treatment conditions but not under the control treatment condition.

The within SWR/J strain comparisons among treatment groups indicate that penetration into the open field is significantly greater by the shock 2 treatment group than by the other treatment groups, by the shock 1 treatment group than by the control group and significantly less by the control treatment group than by the other groups. The within BALB/cJ strain comparisons among treatment groups indicate that penetration

Figure 6. Graphic presentation of strain x treatment interaction of penetration into the open field.



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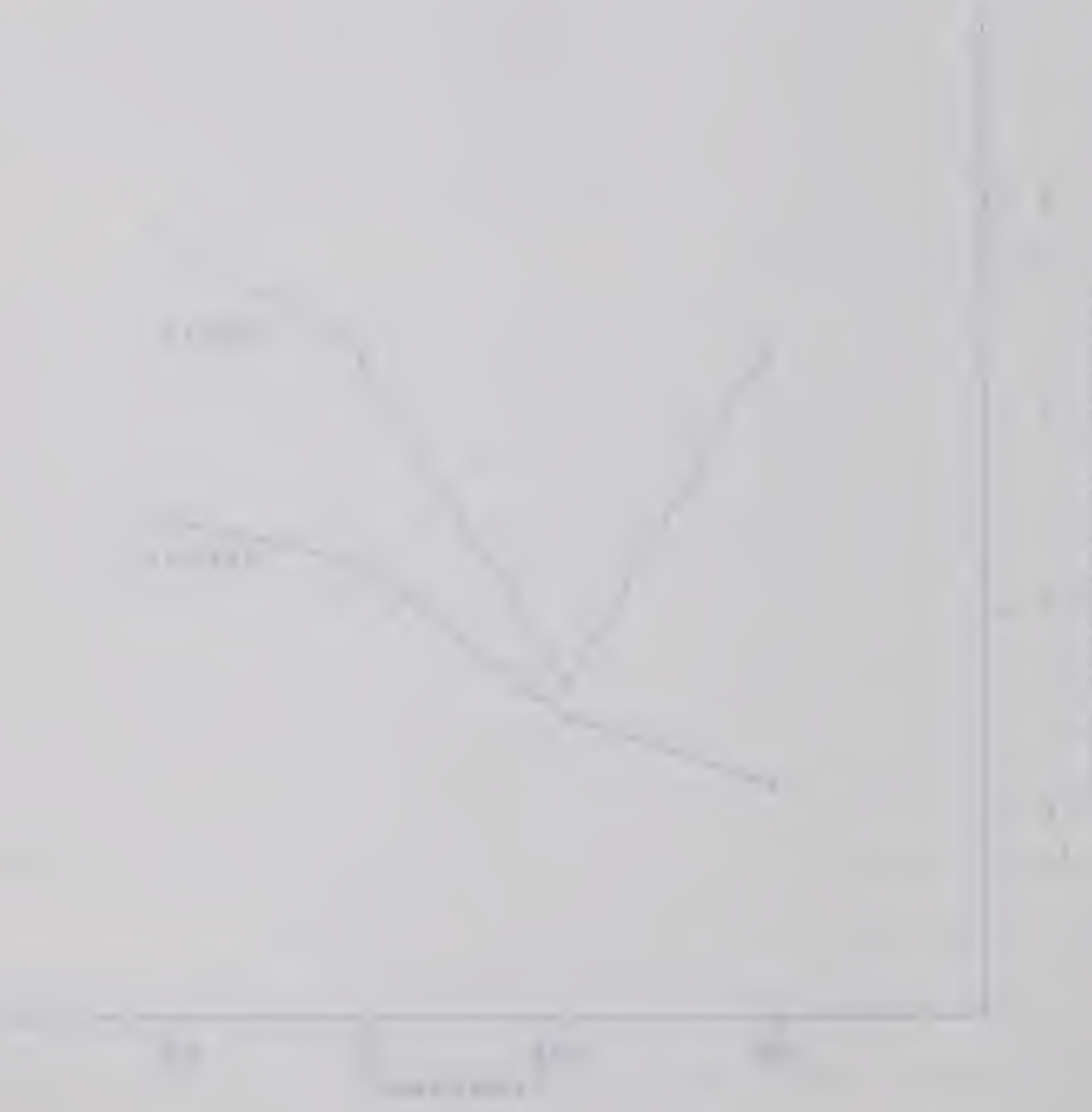


into the open field is significantly greater by the shock 2 treatment group than by the non-disturb and control groups and by the shock 1 treatment group than by the control group. The main effect due to day and the significant strain by day, treatment by day and strain by treatment by day interactions indicate a reduction in penetration on day two for the BALB/cJ strain under the shock 2 treatment condition.

Multiple comparisons among the means of these significant interactions were non-significant.

Straightaway activity

A summary of the analysis of variance of straightaway activity is presented in Table 3. The significant main effects due to strain and treatment are not independent and their significant interaction is graphically presented in Figure 7. It is evident from this graph that the activity of the SWR/J strain is greater than of the BALB/cJ strain. However the between strain comparisons for particular treatment conditions were non-significant.

The within SWR/J strain comparisons among treatment groups indicate the shock 2 treatment group is significantly more active than the control and non-disturb groups and the shock 1 treatment group is significantly more active than the non-disturb group. The within BALB/cJ strain comparisons among treatment groups indicate the shock 2 treatment group is significantly more active than the control group.

The significant main effect due to day indicates an increase in activity on day two under all treatment conditions for both strains. Examination of the significant strain by treatment by day interaction indicates that this increase in activity on day two is somewhat greater under the control treatment condition of the BALB/cJ strain.

Multiple comparisons among the means of this interaction were non-significant.

Straightaway latency

A summary of the analysis of variance of latency on the straightaway is presented in Table 3. The significant

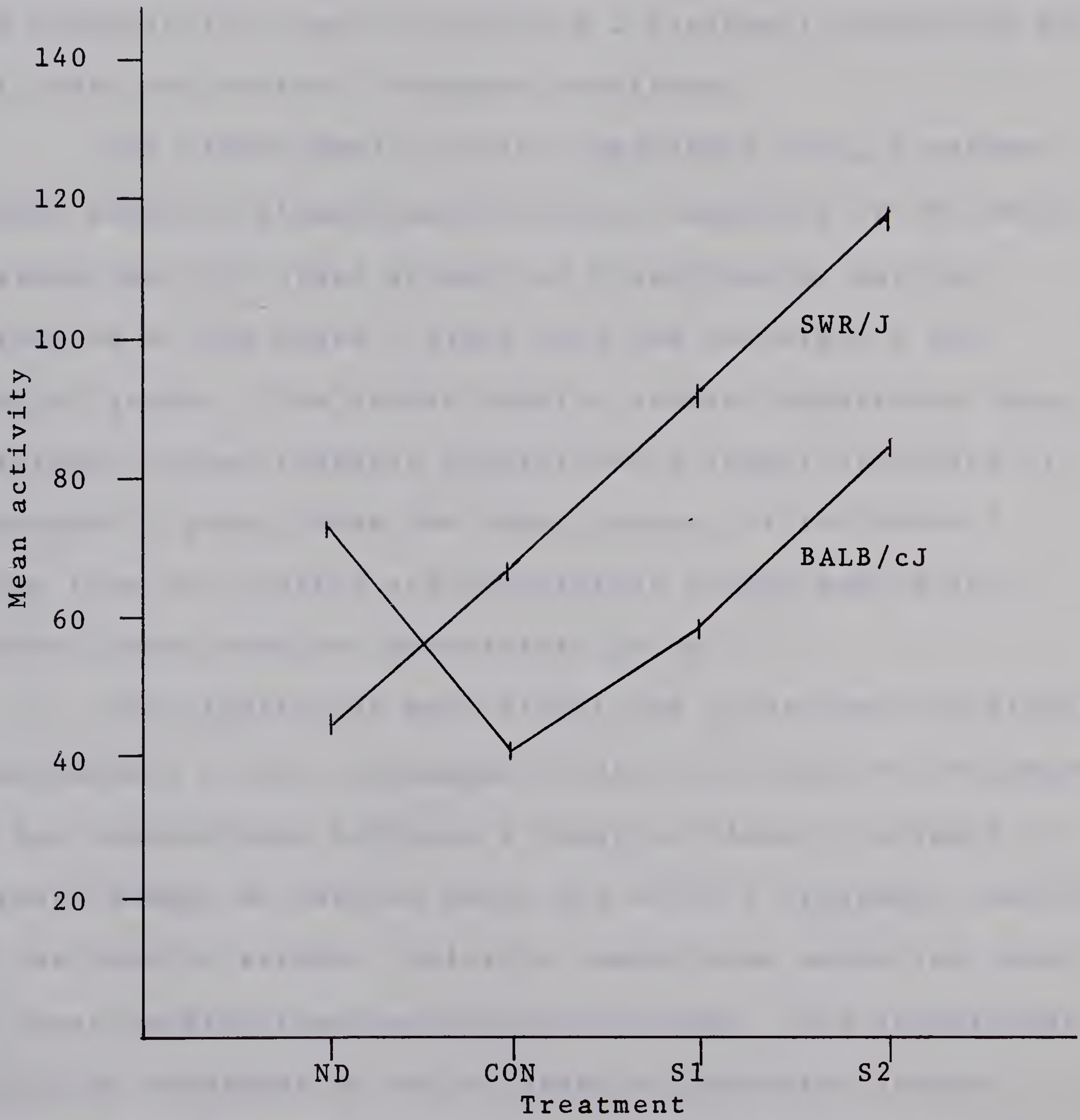
Table 3. Summary of F values of the analysis of variance of measures on the straightaway.

	df	F Activity	F Latency	F Defecation	F Urination
A (strain)	1	18.32*	172.85*	73.95*	3.97*
B (sex)	1	.16	.46	2.54	2.63
A X B	1	.04	1.32	4.91*	1.68
C (treatments)	3	43.71*	10.75*	2.85	4.11*
A X C	3	19.05*	96.84*	7.76*	3.44*
B X C	3	.01	1.53	.25	1.58
A X B X C	3	.21	.22	.11	1.49
S (error)	64				
R (day)	1	10.36*	11.54*	.01	3.28**
A X R	1	3.11	12.56*	.11	.20
B X R	1	.37	.50	.15	.01
A X B X R	1	.26	.89	2.49	.20
C X R	3	2.32	30.75*	4.44*	2.59
A X C X R	3	3.19**	29.94*	1.12	.34
A X B X R	3	.24	.47	.15	1.50
A X B X C X R	3	.24	1.47	1.02	.34
Error	64				
Total	159				

* $p < .01$

** $p < .05$

Figure 7. Graphic presentation of strain x treatment interaction of activity on the straightaway.



main effects due to strain and treatment are not independent and their significant interaction is graphically presented in Figure 8. It is evident from this graph that the latency of the BALB/cJ strain is longer than the latency of the SWR/J strain. The between strain comparisons for particular treatment conditions indicate significant strain differences under the non-disturb, shock 1 and shock 2 treatment conditions but not under the control treatment condition.

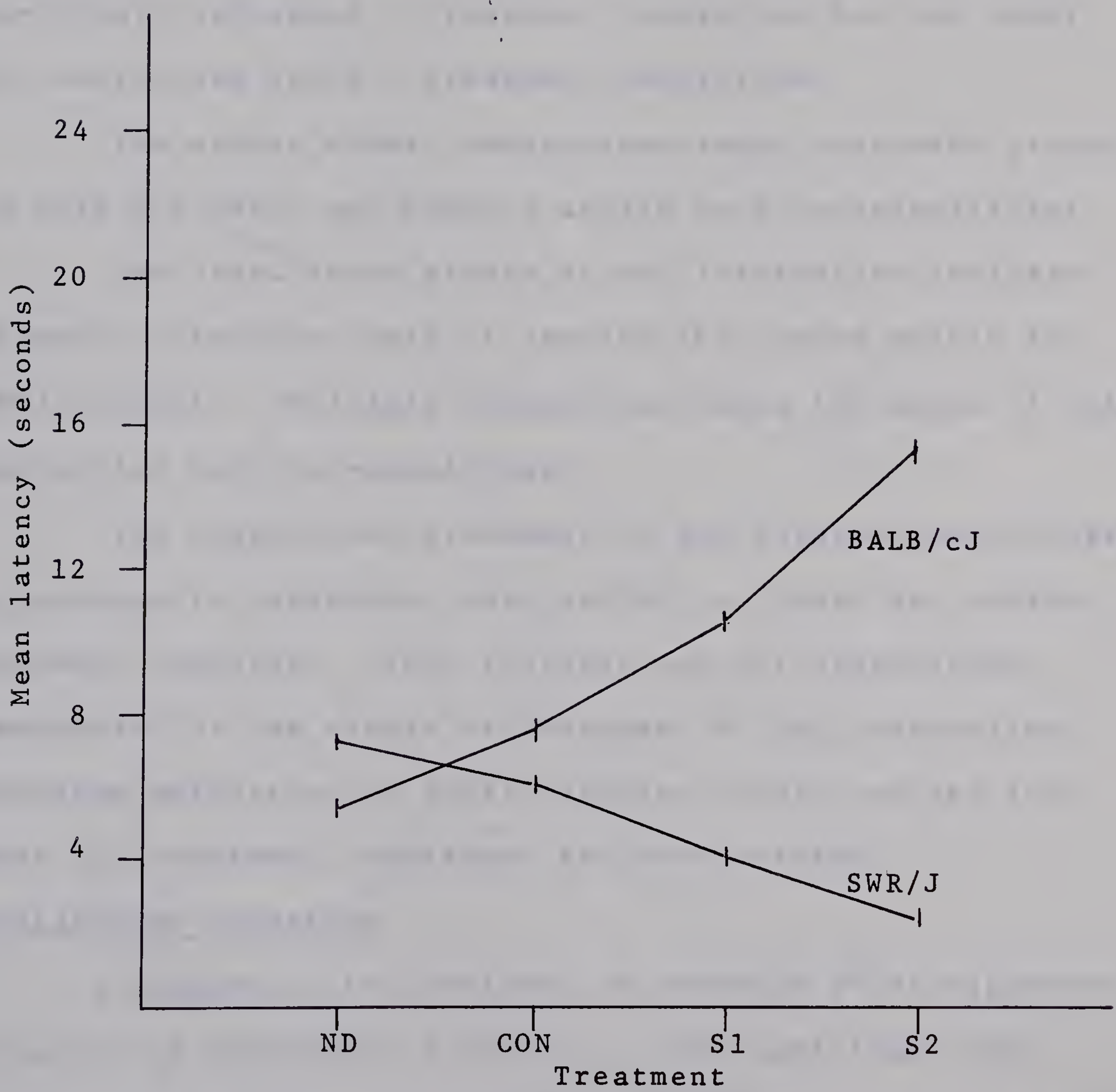
The within SWR/J strain comparisons among treatment groups indicate significantly shorter latencies of the shock 2 group than the other groups and significantly shorter latencies of the shock 1 group than the non-disturb and control groups. The within BALB/cJ strain comparisons among treatment groups indicate significantly longer latencies of the shock 2 group, than the other groups, of the shock 1 group than the control and non-disturb groups and of the control group than the non-disturb group.

The significant main effect due to day and the significant strain by day, treatment by day and strain by treatment by day interactions indicate a disproportionate increase in latency length on day two under the shock 2 treatment condition of the BALB/cJ strain. Multiple comparisons among the means of these interactions were non-significant. The significant strain by treatment by day interaction indicates latency performance is similar on both days noting the above exception.

Straightaway defecation

A summary of the analysis of variance of straightaway

Figure 8. Graphic presentation of strain x treatment interaction of latency to move on the straightaway.



defecation is presented in Table 3. The significant main effect due to strain is graphically presented by the significant strain by treatment interaction in Figure 9. It is evident from this graph that the rate of defecation is greater for the BALB/cJ strain than for the SWR/J strain. The between strain comparisons for particular treatment conditions indicate significant strain differences under the non-disturb and shock 2 treatment conditions but not under the control and shock 1 treatment conditions.

The within strain comparisons among treatment groups for both the SWR/J and BALB/cJ strain were non-significant.

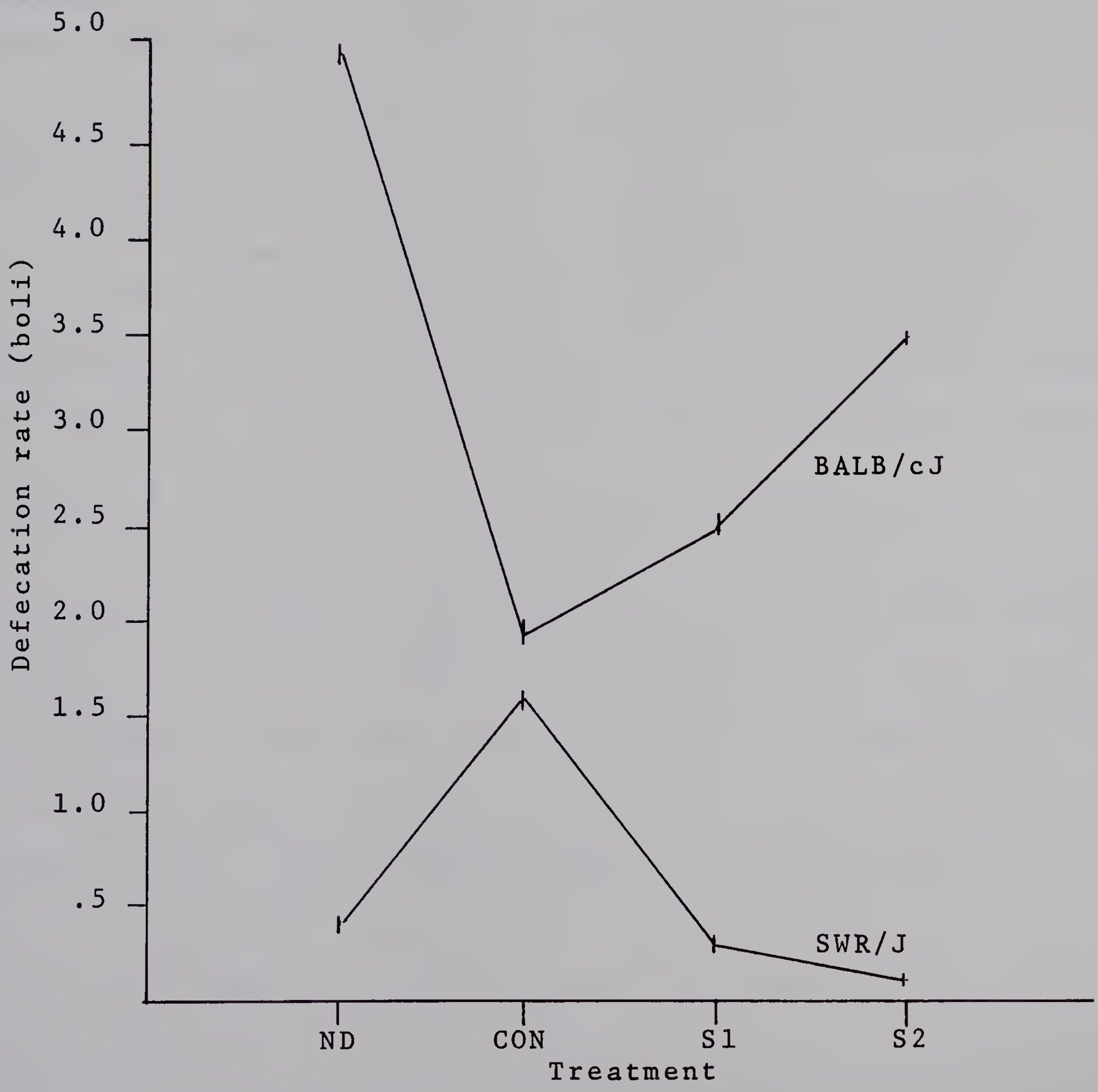
The significant strain by sex interaction indicates a greater defecation rate of females than males within the BALB/cJ strain. Multiple comparisons among the means of this interaction were non-significant.

The significant treatment by day interaction indicates an increase in defecation rate on day two under the control treatment condition. This increase was not significant. Examination of the strain by treatment by day interaction indicates defecation is fairly similar on day one and two under all treatment conditions for both strains.

Straightaway urination

A summary of the analysis of variance of straightaway urination is presented in Table 3. The significant main effect due to strain indicates the BALB/cJ strain has a greater urination rate than the SWR/J strain. Multiple comparisons among the means of the significant main effect due to treat-

Figure 9. Graphic presentation of strain x treatment interaction of defecation on the straightaway.



ment and of the significant strain by treatment interaction were non-significant. The significant main effect due to day indicates that urination is reduced on day two for both strains. Examination of the strain by treatment by day interaction indicates this reduction in urination on day two is consistent for both strains under all treatment conditions.

Latency to enter pipe, trial 1

A summary of the analysis of variance of latency to enter the stovepipe, trial 1, is presented in Table 4. The significant main effects due to strain and treatment are not independent and their significant interaction is graphically presented in Figure 10. It is evident from this graph that latency to enter the stovepipe is longer for the BALB/cJ strain than the SWR/J strain. The between strain comparisons for particular treatment conditions indicate significant strain differences under all four treatment conditions.

The within SWR/J strain comparisons among treatment groups were not significant. The within BALB/cJ strain comparisons among treatment groups indicate the shock 2 treatment group has significantly longer latencies than the other treatment groups.

The significant main effect due to day and the significant strain by day and treatment by day interactions indicate a decrease in latency on day two for both strains and under all treatment conditions. This decrease in latency tends to be somewhat greater for the BALB/cJ strain than the SWR/J strain and for the two shock treatment conditions than for the non-disturb and control treatment conditions. Multiple comparisons among the means of these interactions were non-significant.

Latency to emerge from stove pipe, trial 1

A summary of the analysis of variance of latency to emerge from the stovepipe, trial 1, is presented in Table 4.

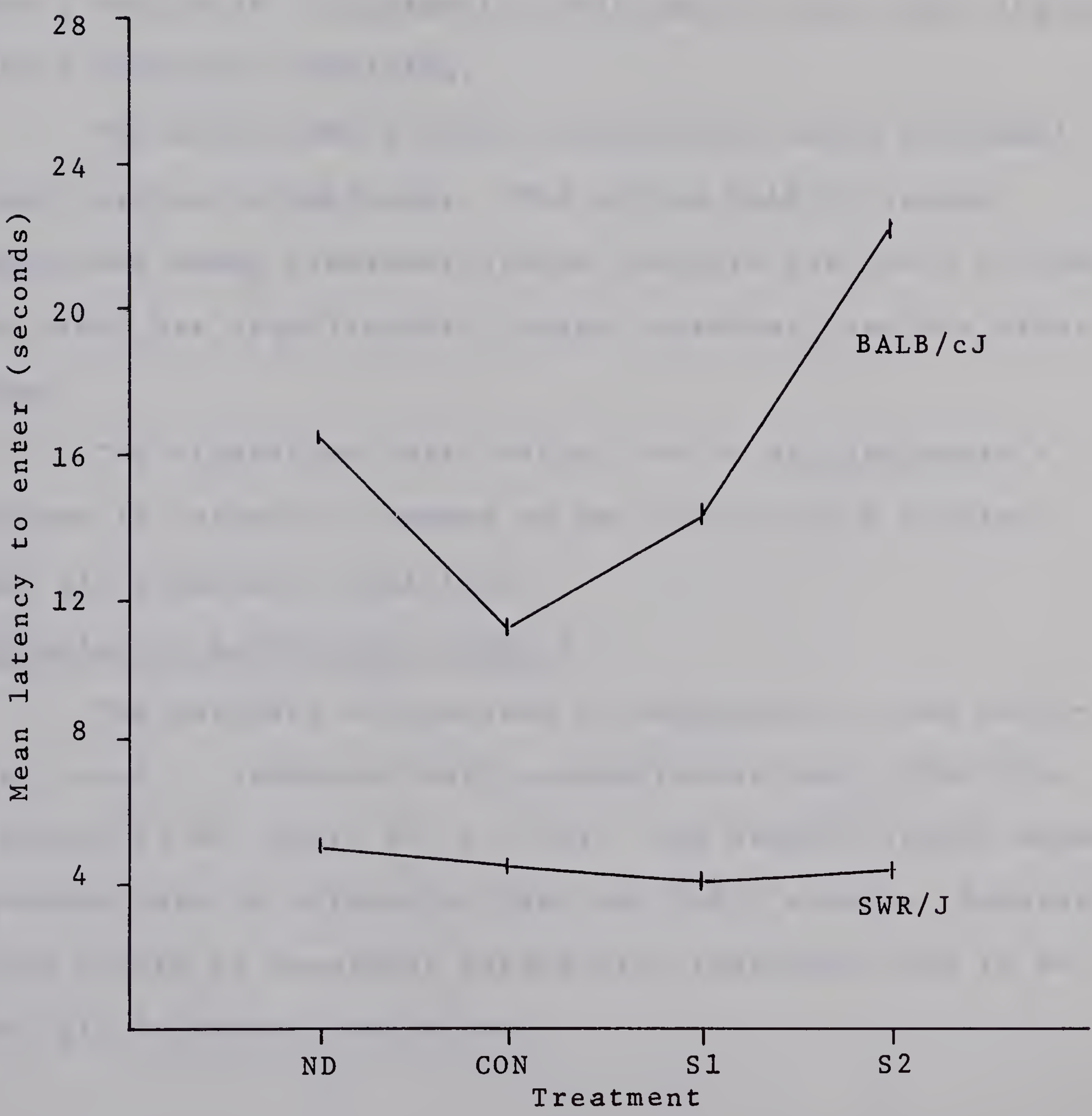
Table 4. Summary of F values of the analysis of variance of latency measures in the stovepipe.

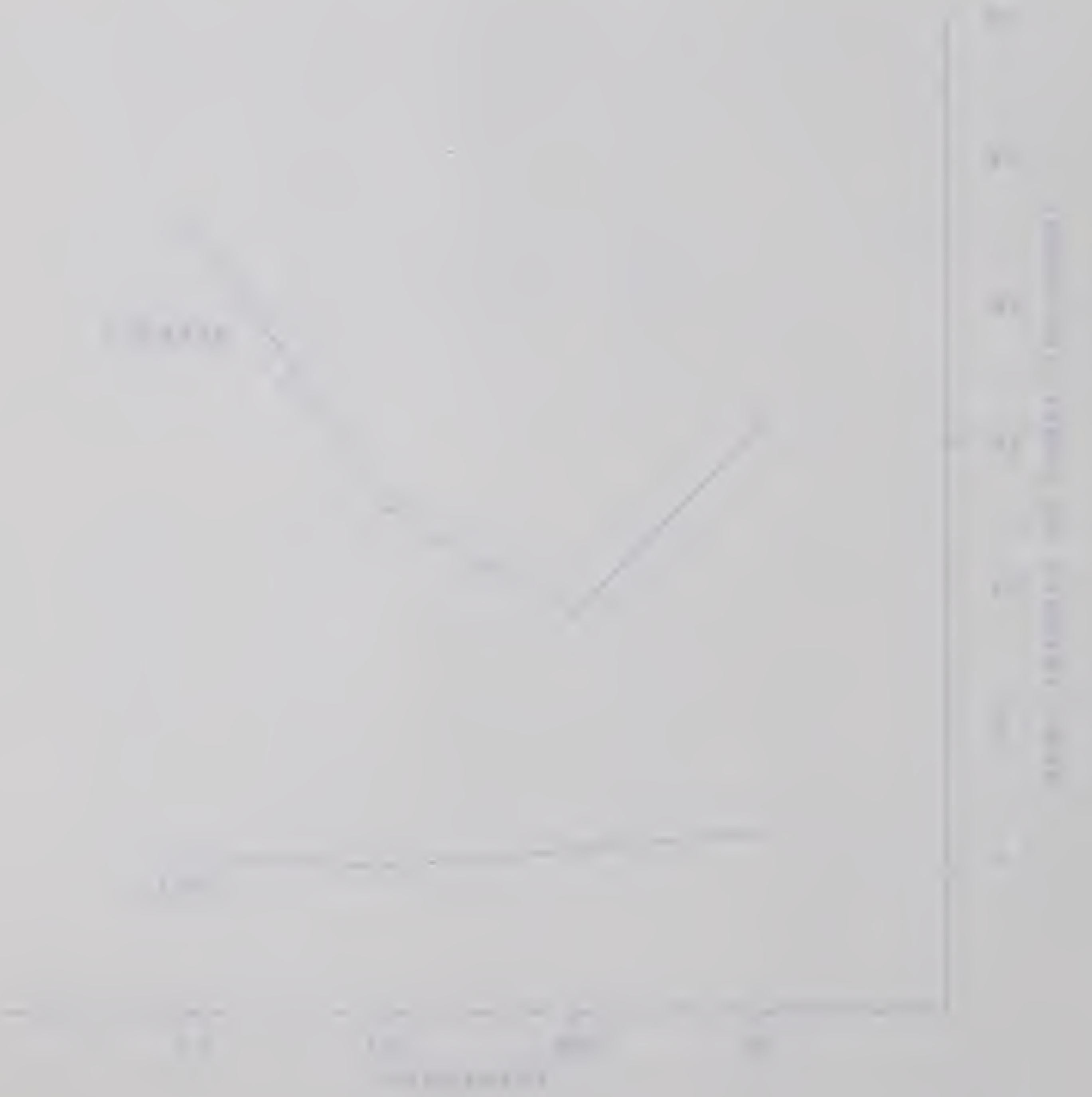
	df	Lat. enter 1. F	Lat. emerge 1. F	Lat. enter 2. F	Lat. emerge 2. F
A (strain)	1	372.52*	91.82*	575.63*	224.71*
B (sex)	1	1.08	.02	.08	.99
A X B	1	.12	.01	1.40	.06
C (treatments)	3	19.83*	14.87*	109.73*	48.86*
A X C	3	19.06*	29.34*	117.98*	82.42*
B X C	3	.27	.18	2.19	1.06
A X B X C	3	.36	.14	1.80	.48
S (error)	64				
R (day)	1	28.14*	8.76*	12.94*	2.05
A X R	1	4.23**	1.36	13.45*	4.25**
B X R	1	1.18	1.03	.30	1.12
A X B X R	1	1.16	.27	.07	.53
C X R	3	6.13*	2.78	7.83*	.61
A X C X R	3	3.78	1.23	1.99	.48
B X C X R	3	1.49	.40	.53	2.61
A X B X C X R	3	.18	.52	1.55	3.44
Error	64				
Total	159				

* $p < .01$

** $p < .05$

Figure 10. Graphic presentation of strain x treatment interaction of latency to enter, trial 1, the stovepipe.





The significant main effects due to strain and treatment are not independent and their significant interaction is presented in Figure 11. It is evident from this graph that the BALB/cJ strain has longer latencies than the SWR/J strain. The between strain comparisons for particular treatment conditions indicate significant strain differences under the control, shock 1 and shock 2 treatment conditions but not under the non-disturb treatment condition.

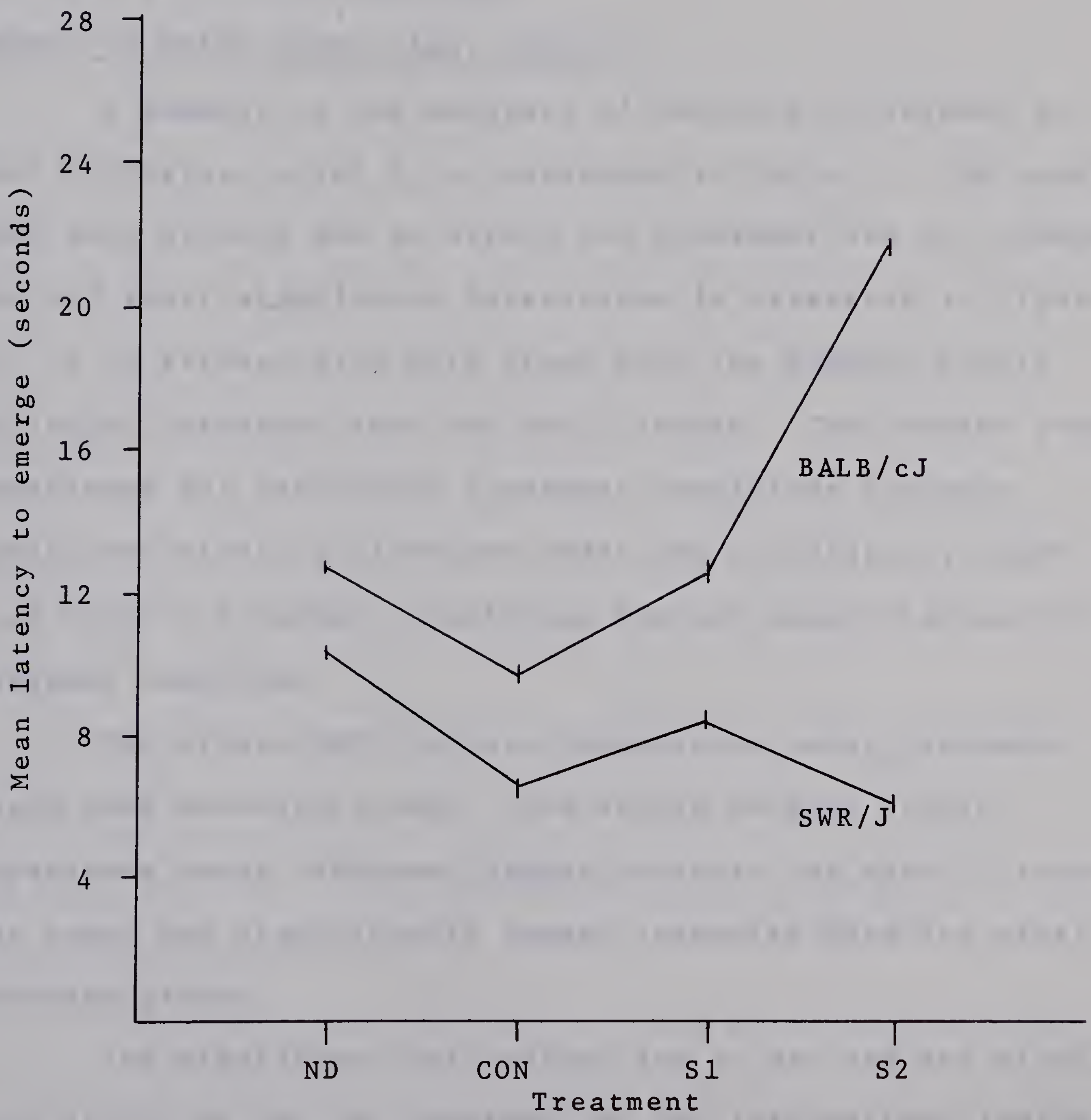
The within SWR/J strain comparisons among treatment groups were non-significant. The within BALB/cJ strain comparisons among treatment groups indicate the shock 2 treatment group has significantly longer latencies than the other groups.

The significant main effect due to day indicates a decrease in latency to emerge on day two for both strains under all treatment conditions.

<u>Defecation in stove pipe, trial 1</u>

The analysis of variance of defecation in the stove-pipe, trial 1, indicates only a significant main effect due to strain (4.81, df=1, 64, $p < .05$). The BALB/cJ strain showed a greater rate of defecation than the SWR/J strain. Examination of the strain by treatment interaction indicates this is so under all treatment conditions.

Figure 11. Graphic presentation of strain x treatment interaction of latency to emerge, trial 1, from the stovepipe.



Urination in stove pipe, trial 2

The analysis of variance of urination in the stovepipe, trial 1, indicates only a significant main effect due to strain (6.07, df=1, 64, $p < .01$). The BALB/cJ strain showed a greater rate of urination than the SWR/J strain. Examination of the strain by treatment interaction indicates this is so under all treatment conditions.

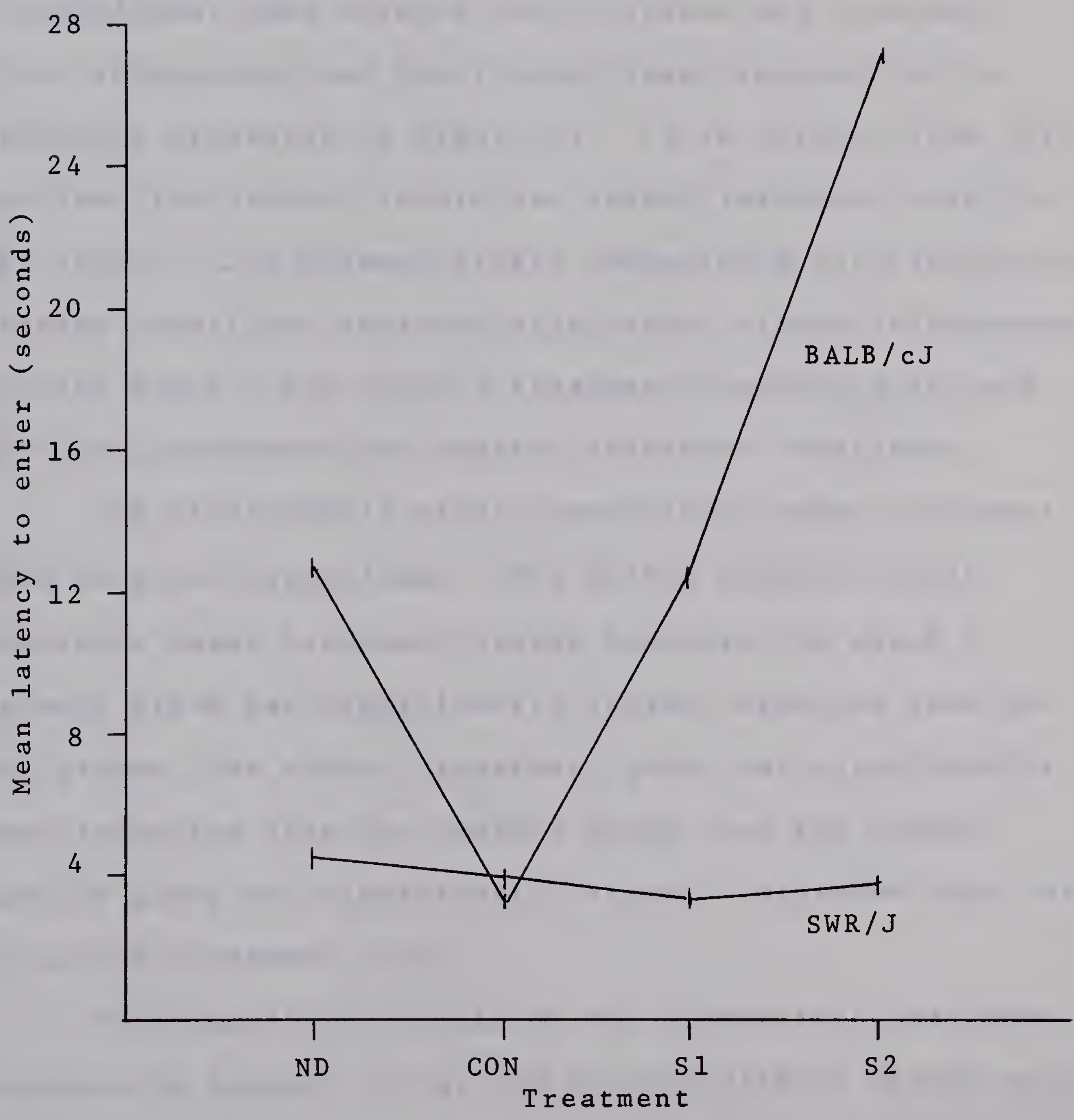
Latency to enter stove pipe, trial 2

A summary of the analysis of variance of latency to enter stovepipe, trial 2, is presented in Table 4. The significant main effects due to strain and treatment are not independent and their significant interaction is presented in Figure 12. It is evident from this graph that the BALB/cJ strain has longer latencies than the SWR/J strain. The between strain comparisons for particular treatment conditions indicate significant strain differences under the non-disturb, shock 1 and shock 2 treatment conditions but not under the control treatment condition.

The within SWR/J strain comparisons among treatment groups were non-significant. The within BALB/cJ strain comparisons among treatment groups indicate the shock 2 treatment group has significantly longer latencies than the other treatment groups.

The significant main effect due to day and the significant strain by day and treatment by day interactions indicate a decrease in latency on day two for both strains under all treatment conditions. This decrease in latency is more marked

Figure 12. Graphic presentation of strain x treatment interaction of latency to enter, trial 2, the stovepipe.



for the BALB/cJ strain under the control treatment condition. Multiple comparisons among the means of these interactions were non-significant.

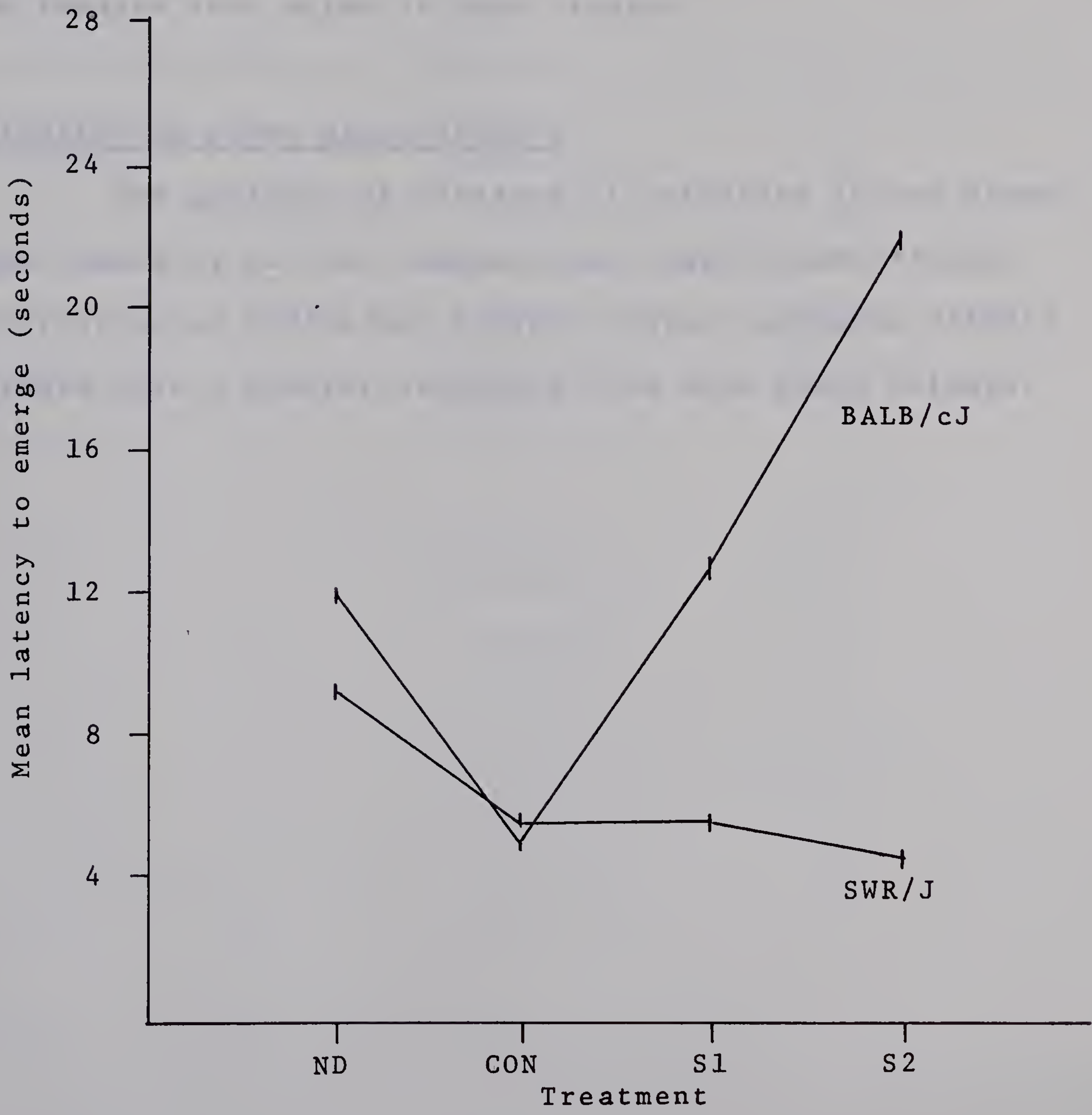
Latency to emerge from stove pipe, trial 2

A summary of the analysis of variance of latency to emerge from stovepipe, trial 2, is presented in Table 4. The significant main effects due to strain and treatment are not independent and their significant interaction is graphically presented in Figure 13. It is evident from this graph that the BALB/cJ strain has longer latencies than the SWR/J strain. The between strain comparisons for particular treatment conditions indicate significant strain differences under the shock 1 and shock 2 treatment conditions but not under the non-disturb and control treatment conditions.

The within SWR/J strain comparisons among treatment groups were non-significant. The within BALB/cJ strain comparisons among treatment groups indicate the shock 2 treatment group has significantly longer latencies than the other groups, the shock 1 treatment group has significantly longer latencies than the control group, and the control treatment group has significantly shorter latencies than the non-disturb treatment group.

The significant strain by day interaction indicates a decrease in latency on day two for the BALB/cJ strain only. Multiple comparisons among the means of this interaction were non-significant.

Figure 13. Graphic presentation of strain x treatment interaction of latency to emerge, trial 2, from the stovepipe.



Defecation in stove pipe, trial 2

The analysis of variance of defecation in the stove-pipe, trial 2, indicates two significant main effects due to strain (5.96, df=1, 64, $p < .01$), and sex (7.94, df=1, 64, $p < .01$). The BALB/cJ strain has a greater defecation rate than the SWR/J strain under all treatment conditions and females than males of both strains.

Urination in stove pipe, trial 2

The analysis of variance of urination in the stove-pipe, trial 2, did not indicate any significant effects. Observation of individual subject scores indicates BALB/cJ animals have a greater urination rate than SWR/J animals.

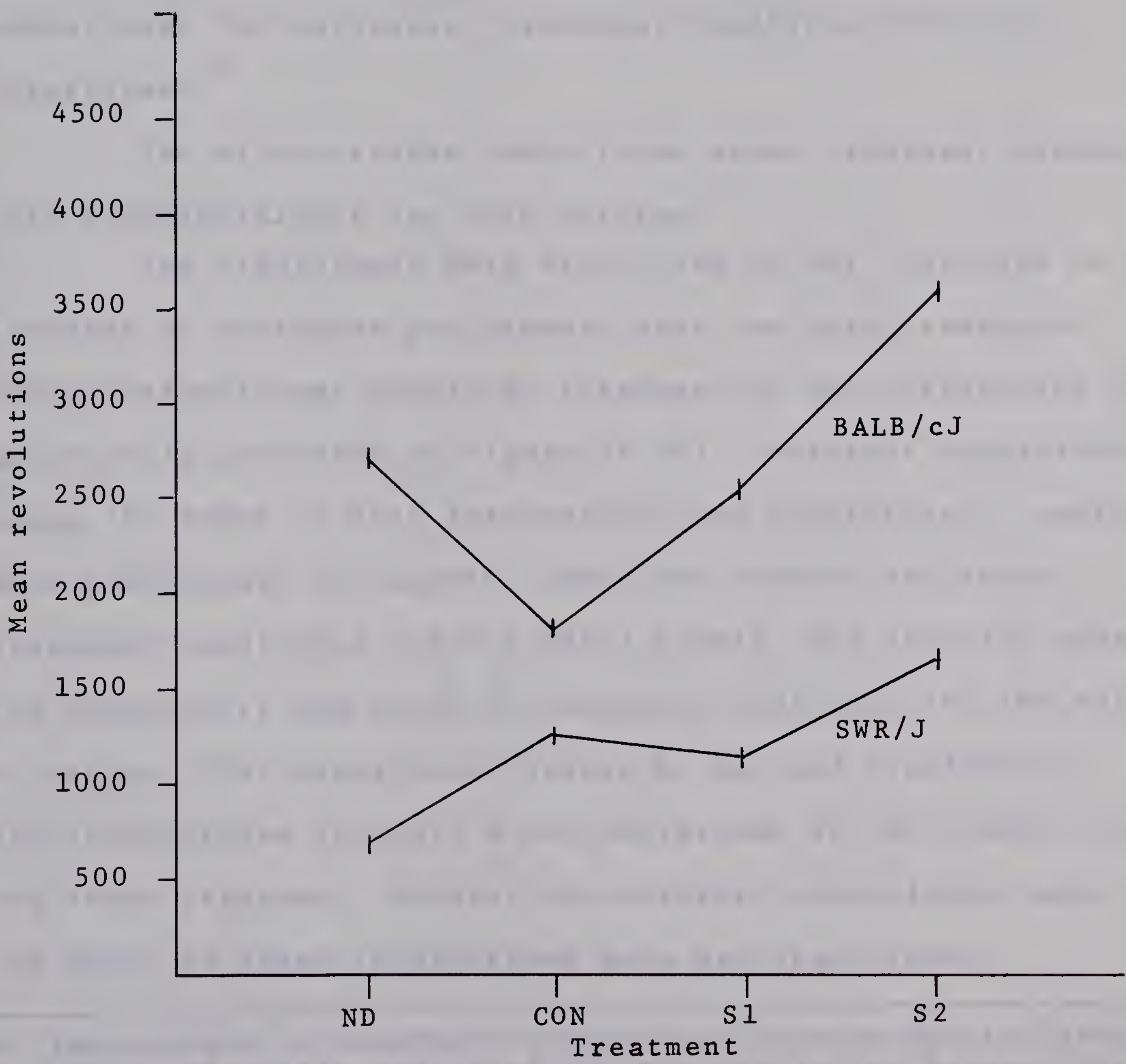
Table 5. Summary of the analysis of variance of revolutions in the activity wheel.

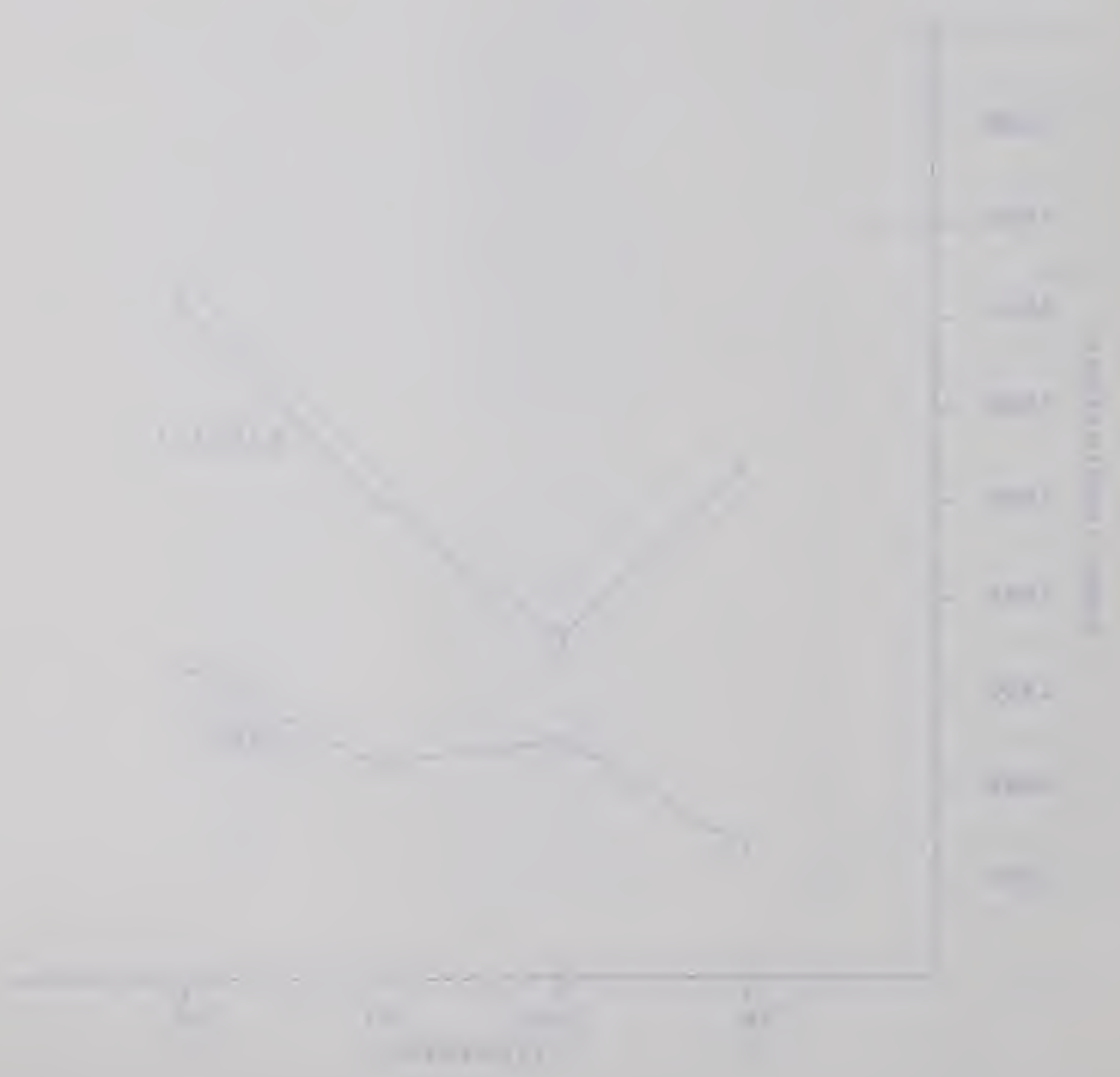
Source of variance	df	Mean square	F
A (strain)	1	170490000.00	44.43*
B (sex)	1	2999100.00	.78
A X B	1	15638.00	.40
C (treatments)	3	25070000.00	6.53*
A X C	3	13459000.00	3.50**
B X C	3	7636800.00	1.99
A X B X C	3	9184000.00	2.39
S (error)	64	3836900.00	
R (day)	3	778640000.00	70.22*
A X R	3	25549000.00	23.71*
B X R	3	682620.00	.63
A X B X R	3	1371100.00	1.27
C X R	9	2343700.00	2.17**
A X C X R	9	6042700.00	5.60*
B X C X R	9	1216500.00	1.12
A X B X C X R	9	871110.00	.80
Error	192	1077400.00	
Total	319		

* $p < .01$

** $p < .05$

Figure 14. Graphic presentation of strain x treatment interaction of activity in the activity wheel.





Avoidance conditioning - correct responses

A summary of the analysis of variance of correct responses in avoidance conditioning is presented in Table 6. The significant strain by treatment interaction is graphically presented in Figure 15 (a). It is evident from this graph that there is no difference in avoidance performance between the two strains. The between strain comparisons for particular treatment conditions were non-significant.*

The within strain comparisons among treatment groups were non-significant for both strains.+

The significant main effect due to day indicates an increase in avoidance performance over the three sessions. The non-significant strain by treatment by day interaction is graphically presented in Figure 15 (b). Multiple comparisons among the means of this interaction were significant. Avoidance performance is superior under the control and shock 1 treatment conditions for the SWR/J strain, and superior under the non-disturb and shock 2 treatment conditions for the BALB/cJ strain. The significant strain by day and treatment by day interactions indicate minor variations in the trends over the three sessions. However the multiple comparisons among the means of these interactions were non-significant.

\+ The absence of treatment effects may also be due to limited number of trials presented and the similarity between treatment stimulation and dependent task.

* This is somewhat disturbing insofar as strain differences on avoidance performance appears faily well established. e.g. Royce & Covington, 1960). However since only 75 trials total were presented in this study this may account for the absence of strain differences.

Table 6. Summary of F values of analysis of variance on measures of avoidance conditioning.

		Avoidance Conditioning		Intertrial activity	
Source of variance	df	Mean square	F	Mean square	F
A (strain)	1	2.01	.17	228230.00	127.64*
B (sex)	1	3.75	.31	90.03	.05
A X B	1	16.01	1.35	4.53	.01
C (treatment)	3	5.93	.50	25195.00	14.09*
A X C	3	109.25	9.24*	8569.20	4.79*
B X C	3	.09	.01	611.08	.34
A X B X C	3	.82	.07	102.98	.05
S (error)	64	11.81		1787.96	
R (day)	2	3308.90	472.55*	19495.00	30.05*
A X R	2	21.65	3.09**	69601.00	107.25*
B X R	2	7.81	1.11	574.46	.88
A X B X R	2	1.42	.20	54.08	.08
C X R	6	23.54	3.36**	6765.40	10.42*
A X C X R	6	11.98	1.71	5562.70	8.57*
B X C X R	6	2.49	.35	583.19	.89
A X B X C X R	6	7.34	1.04	1091.90	1.68
Error	128	7.00		648.91	
Total	239				

* $p < .01$

** $p < .05$

Figure 15 (a). Graphic presentation of strain x treatment interaction of average correct responses over three sessions.

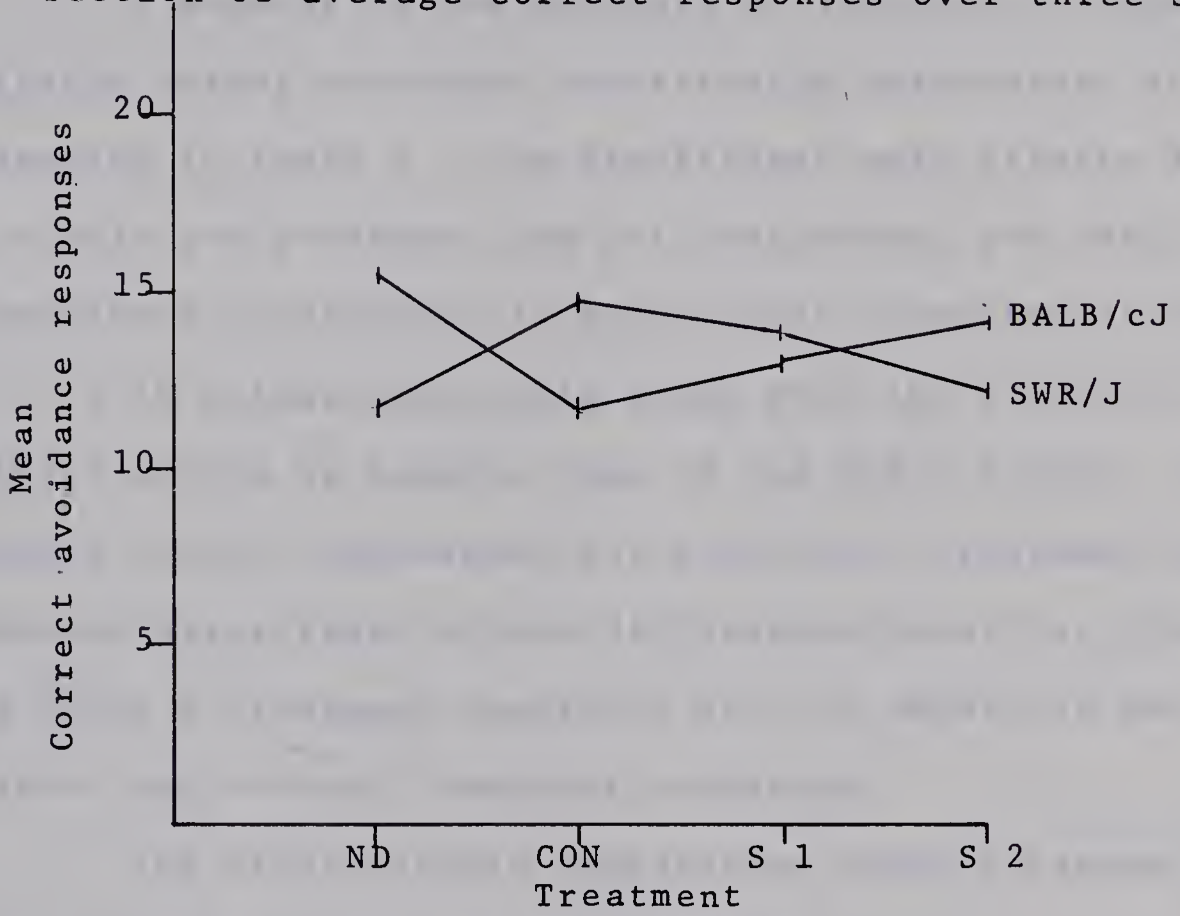
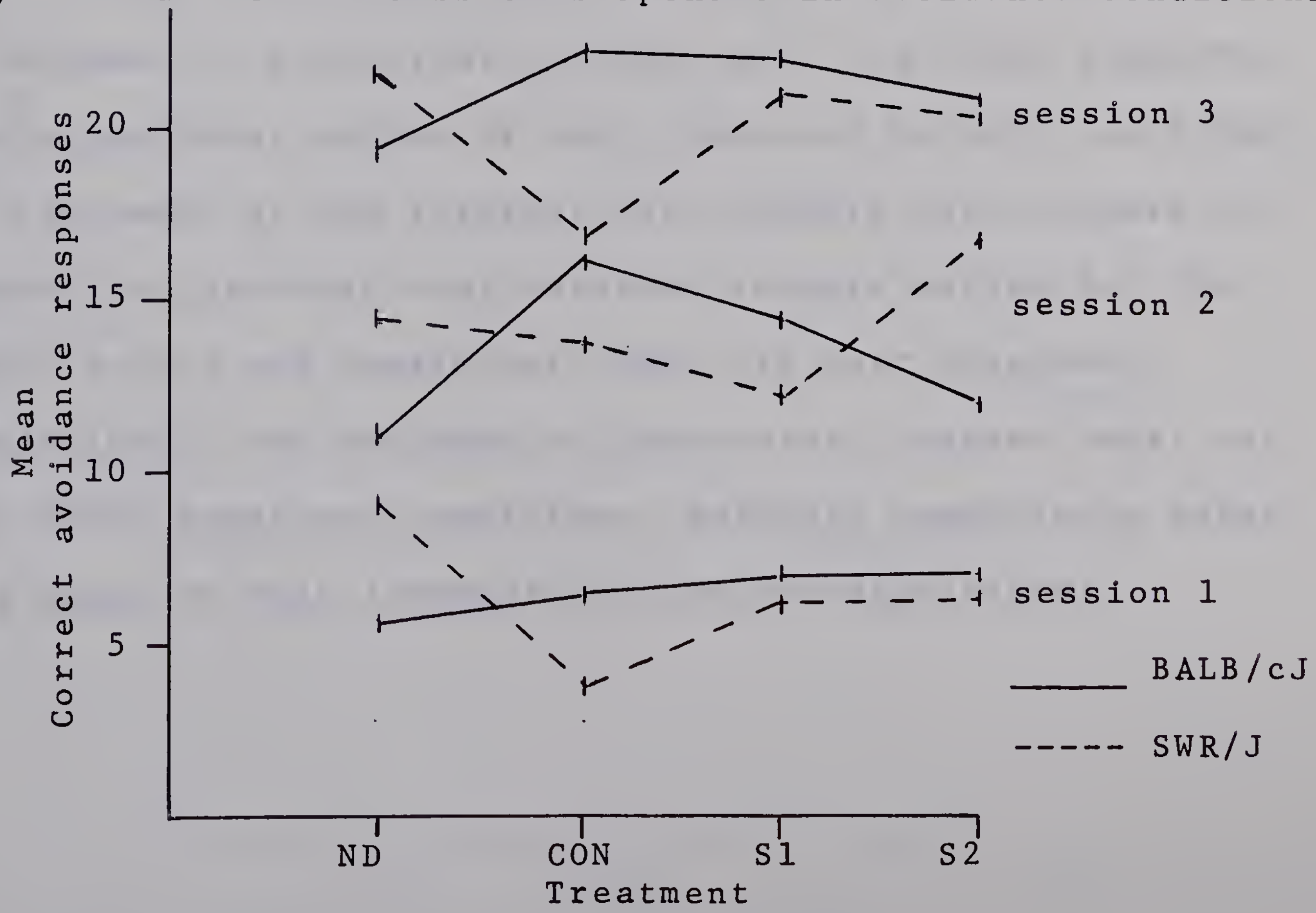
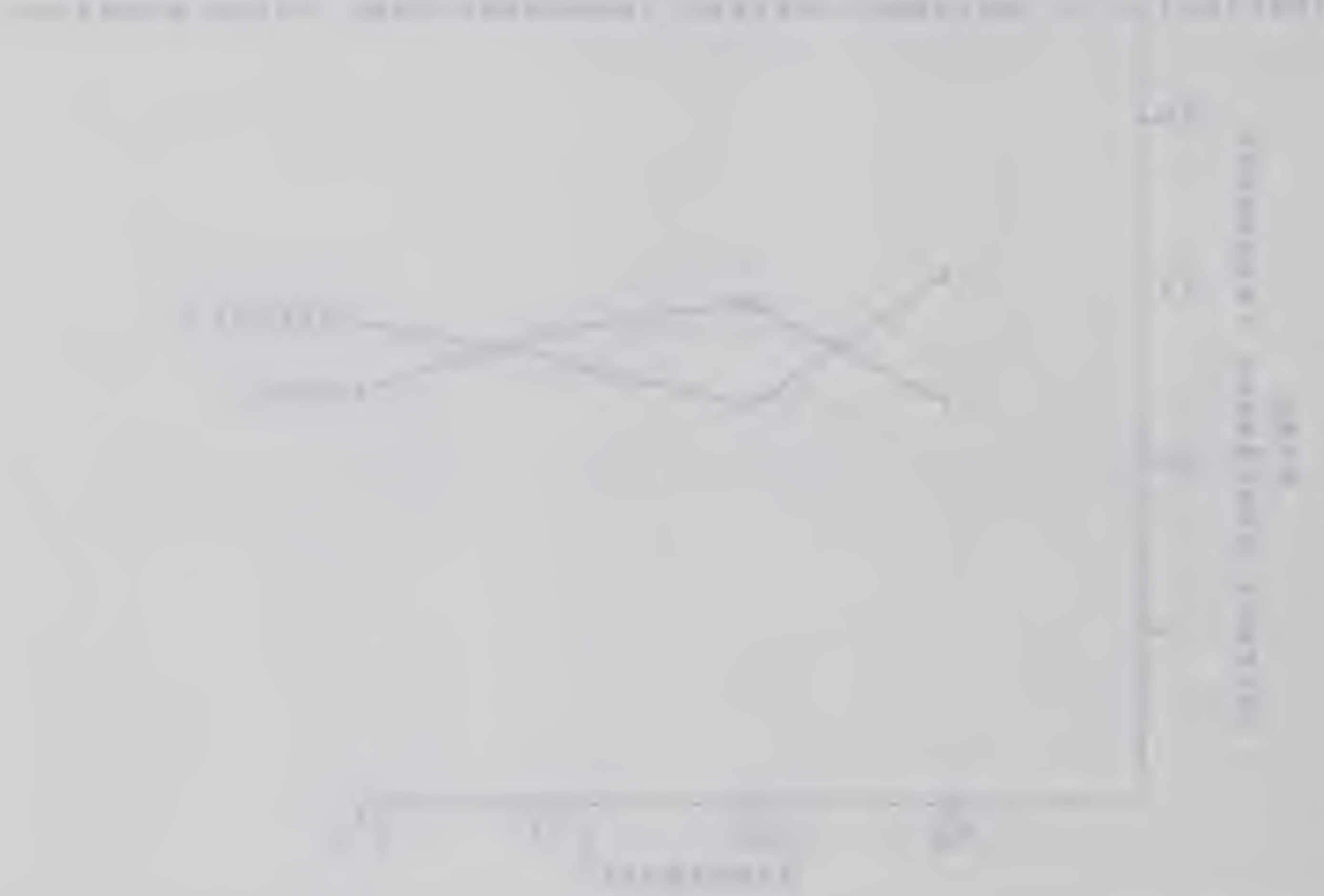


Figure 15 (b). Graphic presentation of strain x treatment x day interaction of correct responses in avoidance conditioning.





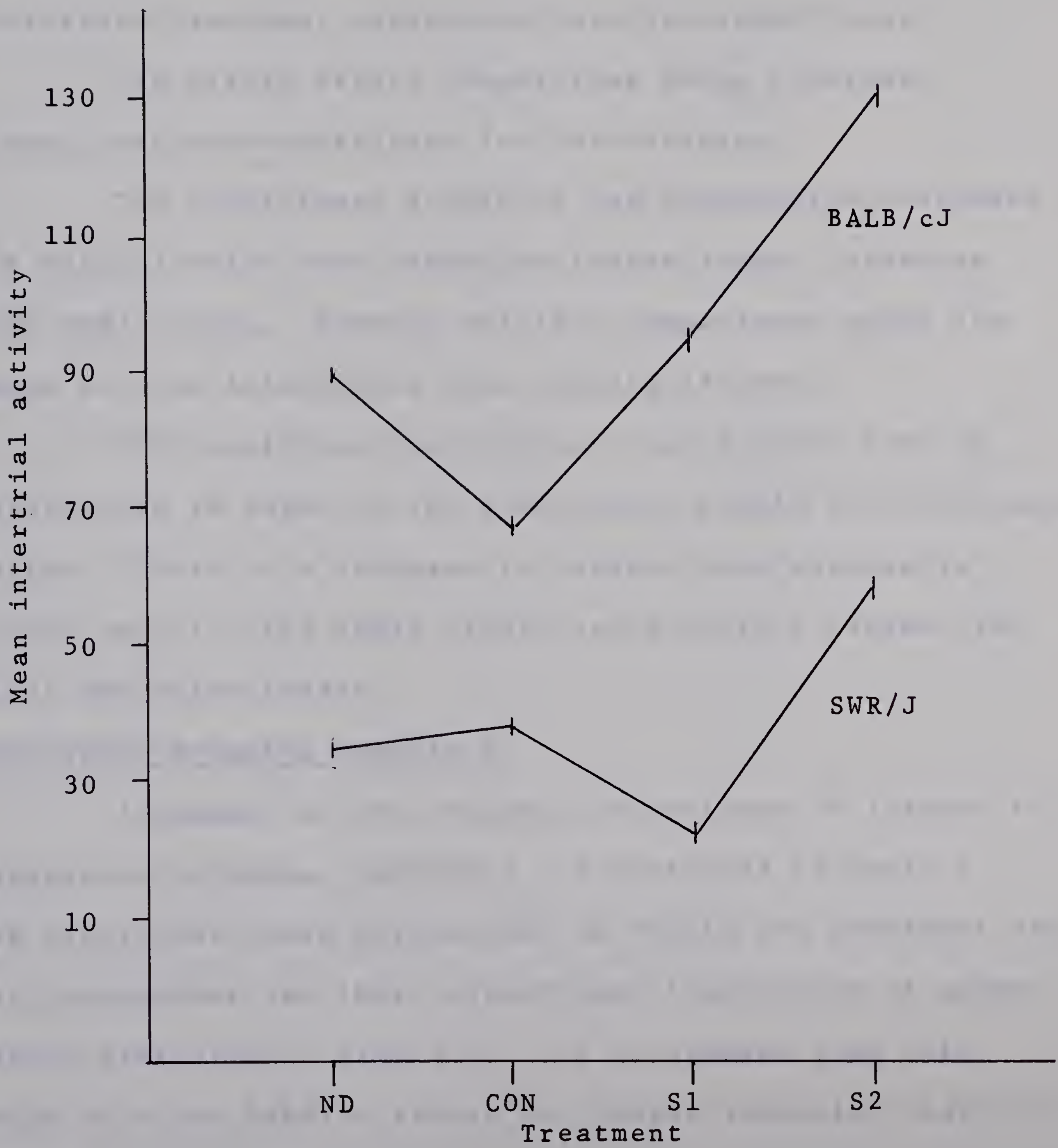
Avoidance conditioning intertrial activity

A summary of the analysis of variance of intertrial activity during avoidance conditioning performance is presented in Table 6. The significant main effects due to strain and treatment are not independent and their significant interaction is graphically presented in Figure 16. It is evident from this graph that the activity of the BALB/cJ strain is greater than of the SWR/J strain. The between strain comparisons for particular treatment conditions indicate significant strain differences under the shock 1 and shock 2 treatment conditons but not under the non-disturb and control treatment conditons.

The within strain comparisons among treatment groups were non-significant for both strains.

The significant main effect due to day indicates a decrease in intertrial activity over the three sessions. The significant strain by day, treatment by day, and strain by treatment by day interactions indicate the decrease in intertrial activity over sessions is more marked for the SWR/J strain and consistent under all four treatment conditions. The decrease is particularly marked under the two shock treatment conditions. Multiple comparisons among the means of this interaction were non-significant.

Figure 16. Graphic presentation of strain x treatment interaction of intertrial activity in avoidance conditioning.



Underwater swimming measure 1

A summary of the analysis of variance of latency in underwater swimming, measure 1, is presented in Table 7. The significant main effect due to strain must be interpreted in terms of the significant strain by treatment interaction graphically presented in Figure 17. It is evident from this graph that the BALB/cJ strain has longer latencies than the SWR/J strain. The between strain comparisons for particular treatment conditions were non-significant.

The within strain comparisons among treatment groups were non-significant for both strains.

The significant strain by sex interaction indicates the BALB/cJ males have disproportionate longer latencies than SWR/J males. However multiple comparisons among the means of this interaction were non-significant.

The significant main effect due to trial must be interpreted in terms of the significant strain by trial interaction. There is a decrease in latency over successive trials only for the SWR/J strain and primarily between the first and third trials.

Underwater swimming measure 2

A summary of the analysis of variance of latency in underwater swimming, measure 2, is presented in Table 7. The significant main effects due to strain and treatment are not independent and their significant interaction is graphically presented in Figure 18. It is evident from this graph that the BALB/cJ strain has longer latencies than the

Table 7. Summary of F values of analysis of variance on measures of underwater swimming.

	df	Measure 1. F	Measure 2. F	Measure 3. F
A (strain)	1	6.22*	179.63*	11.64*
B (sex)	1	.58	5.84*	.09
A X B	1	4.92**	.88	.03
C (treatment)	3	.40	11.41*	3.85**
A X C	3	3.89**	13.35*	4.16*
B X C	3	1.92	1.05	.55
A X B X C	3	.88	2.47	1.34
S (error)	64			
R (measure)	4	4.82*	19.47*	7.12*
A X R	4	5.78*	9.57*	9.89*
B X R	4	.85	.19	1.04
A X B X R	4	.24	3.64*	.61
C X R	12	.43	1.13	.90
A X C X R	12	.67	.58	.93
B X C X R	12	.58	1.22	.62
A X B X C X R	12	1.01	4.94*	.41
Error	256			
Total	399			

* $p < .01$

** $p < .05$

Figure 17. Graphic presentation of strain x treatment interaction of latency, measure 1, of underwater swimming.

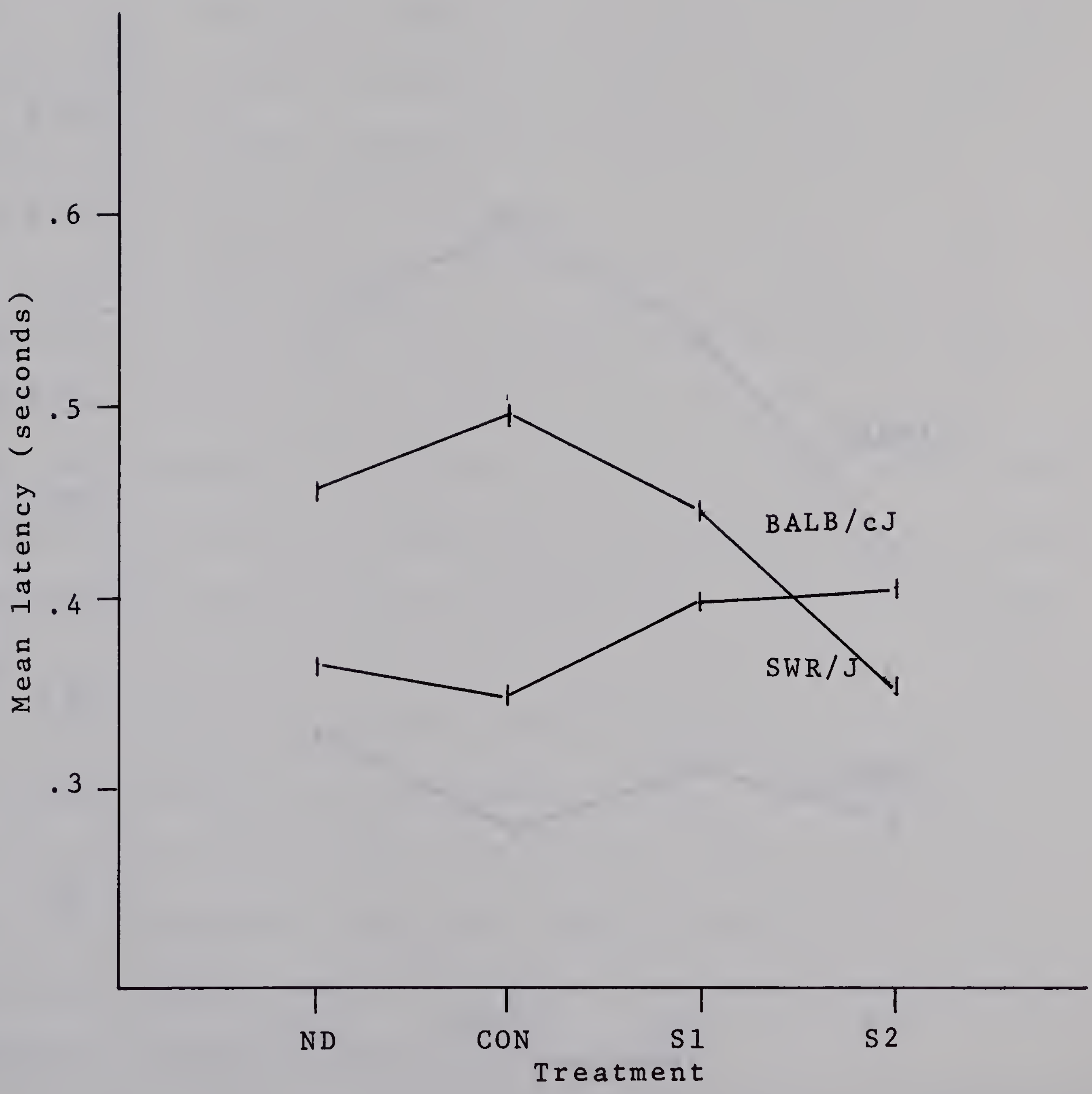
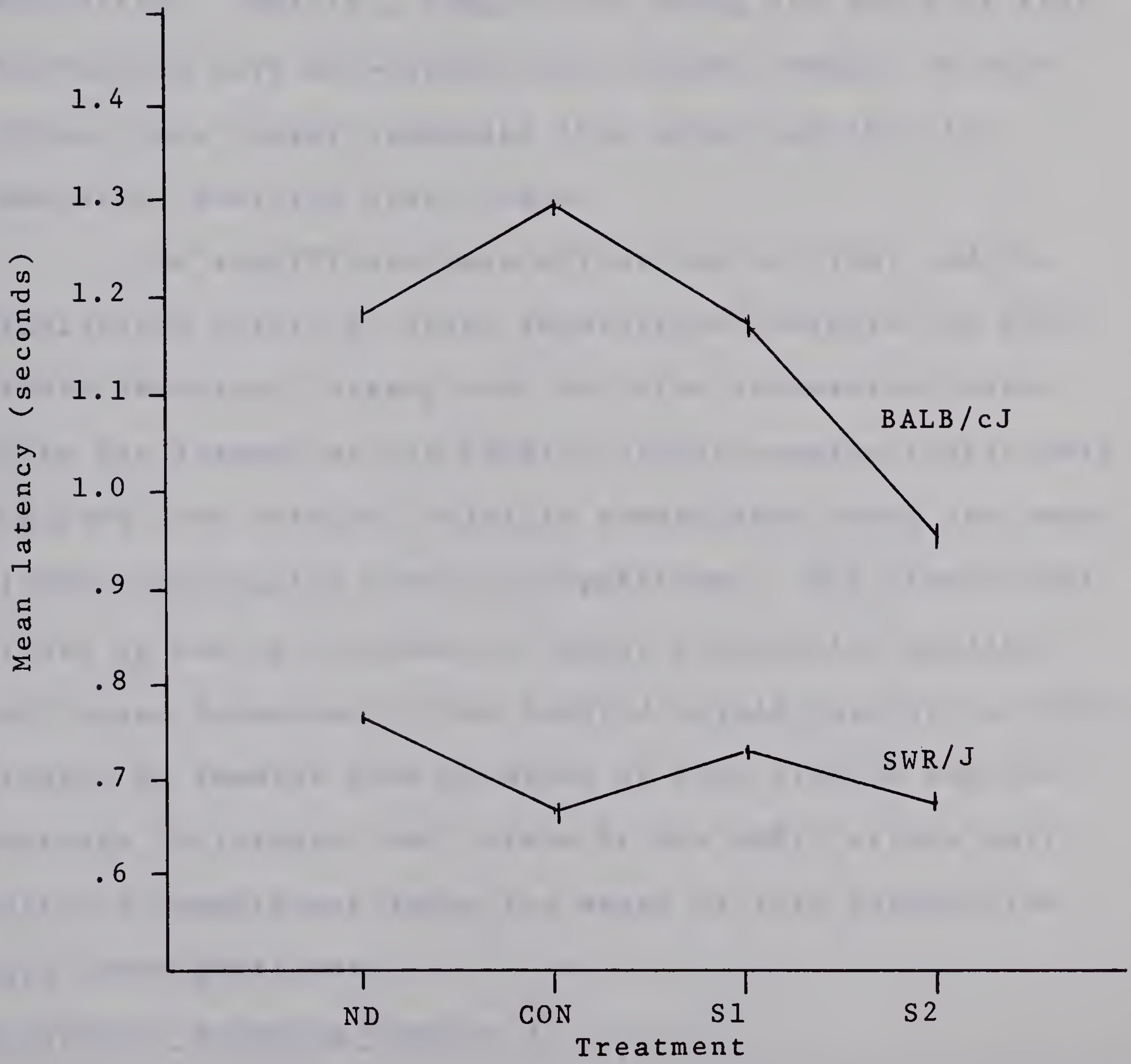
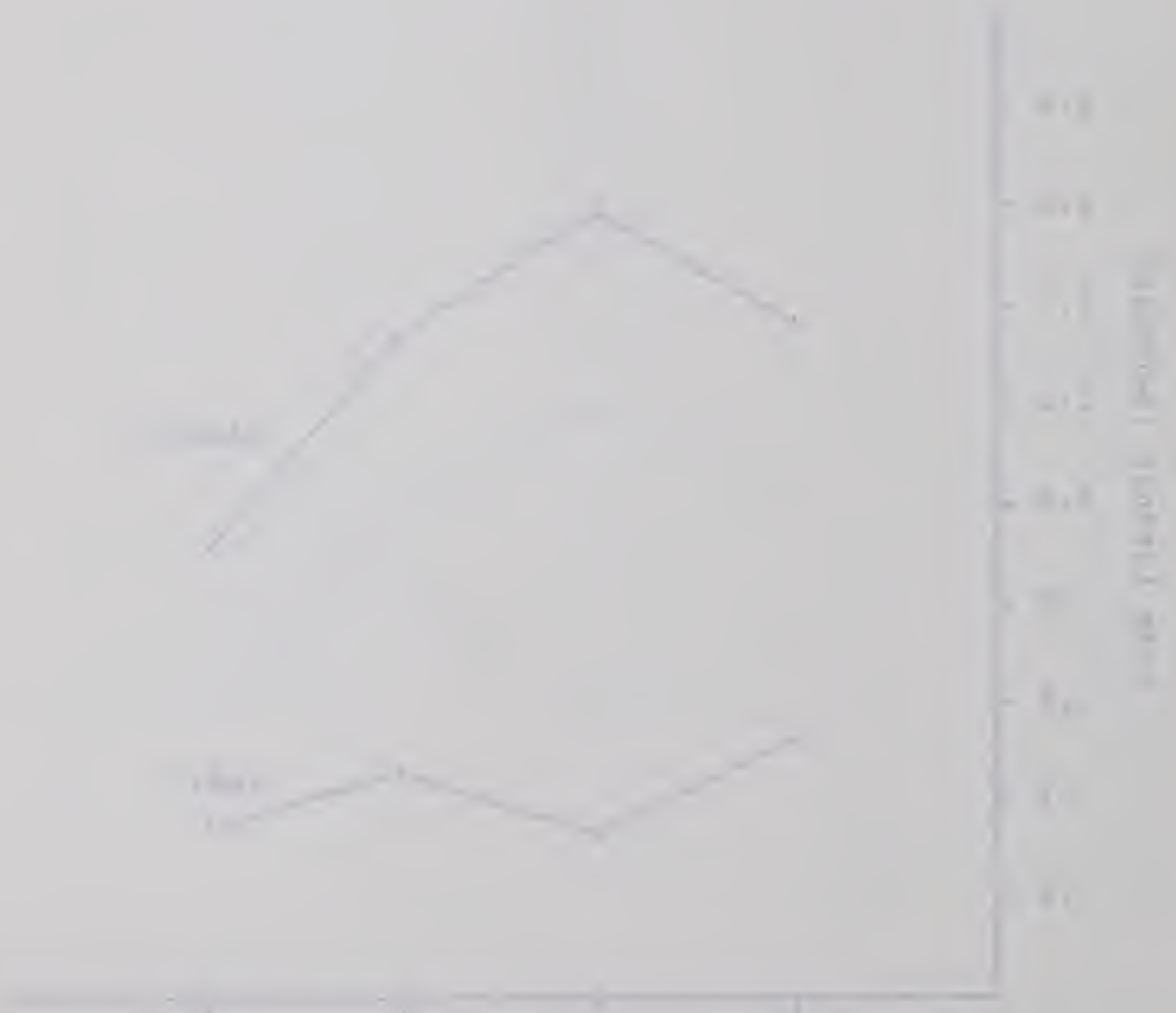


Figure 18. Graphic presentation of strain x treatment interaction of latency, measure 2, of underwater swimming.





SWR/J strain. The between strain comparisons for particular treatment conditions indicate a significant strain difference under the control treatment condition.

The within strain comparisons among treatment groups were non-significant for both strains.

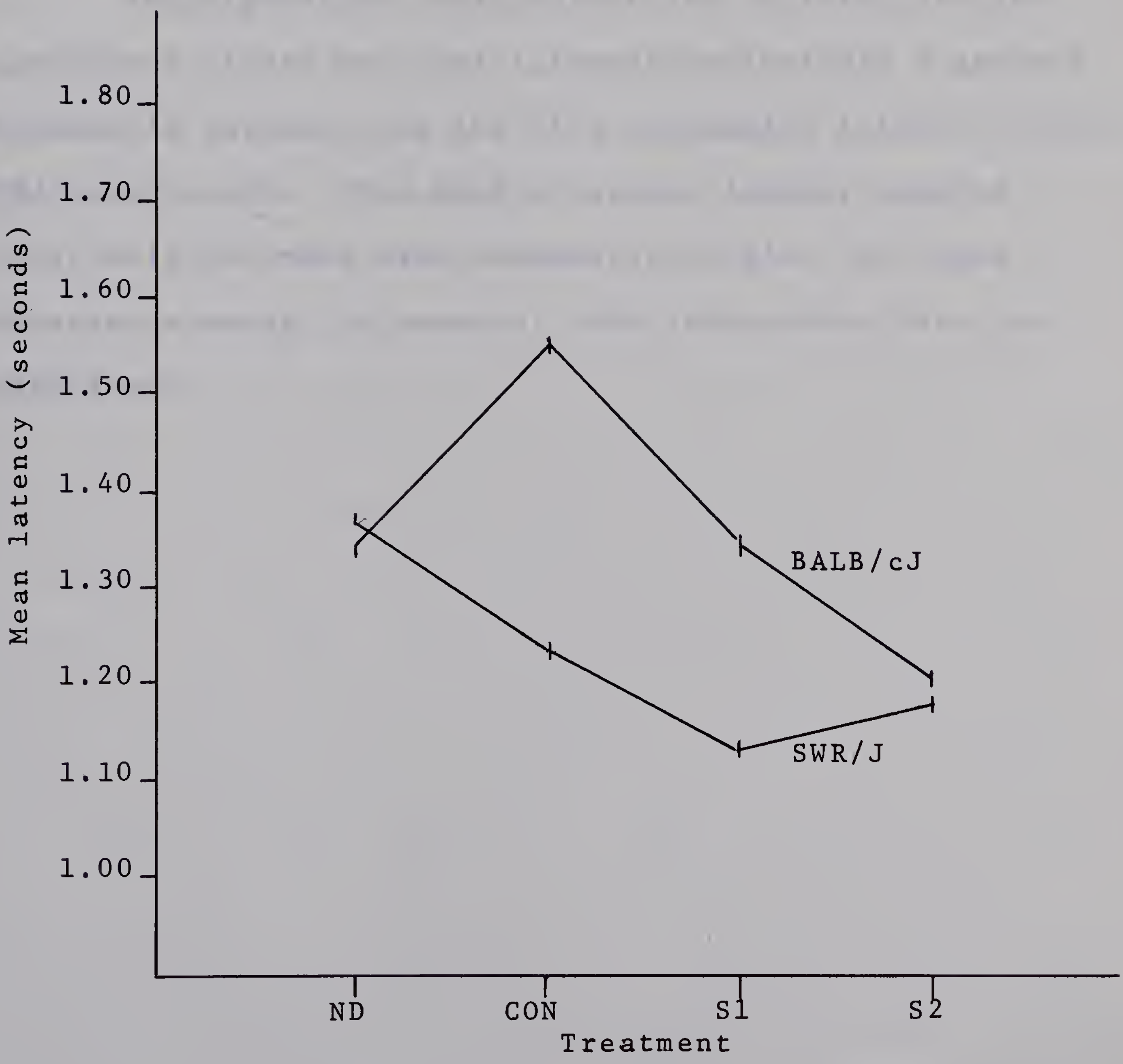
The significant main effect due to sex must be interpreted in terms of the significant strain by sex by trial interaction. Multiple comparisons among the means of this interaction were non-significant however females of both strains have longer latencies than males and this is consistent over the five trials.

The significant main effect due to trial and the significant strain by trial interaction indicate the SWR/J strain decreases latency over the five successive trials while the latency of the BALB/cJ strain remains fairly well the same over trials. Multiple comparisons among the means of this interaction were non-significant. The significant strain by sex by treatment by trial interaction confirms the longer latencies by the BALB/cJ strain than by the SWR/J strain, by females than by males of both strains and the decrease in latency over trials by the SWR/J strain only. Multiple comparisons among the means of this interaction were non-significant.

<u>Underwater swimming measure 3</u>

A summary of the analysis of variance of latency in underwater swimming, measure 3, is presented in Table 7. The significant main effects due to strain and treatment

Figure 19. Graphic presentation of strain x treatment interaction of latency, measure 3, of underwater swimming.



are not independent and their significant interaction is presented in Figure 19. It is evident from this graph that the latency of the BALB/cJ strain is longer than of the SWR/J strain. The between strain comparisons for particular treatment conditions were non-significant.

The within strain comparisons among treatment groups were non-significant for both strains.

The significant main effect due to trial and the significant strain by trial interaction indicate a gradual decrease in latency over the five successive trials for the SWR/J strain only. The BALB/cJ strain latency remains fairly well the same over successive trials. Multiple comparisons among the means of this interaction were non-significant.

Discussion

In terms of the concerns expressed at the beginning or this study it may be concluded:

1. The results of this study indicate that prior stressful stimulation affects later behavior measures of emotional reactivity in the SWR/J and the BALB/cJ mouse. These effects due to treatment were evident on measures of defecation, latency and activity which suggests that the effects of prior treatment are of a relatively general nature, discernable in a variety of dependent tasks, all of which are sufficiently different from the treatment apparatus to exclude the possibility of stimulus generalization. This seems to imply that prior treatment, in this study, affects a generalized response disposition (emotionality or emotional reactivity) which may be elicited in diverse settings, rather than have effects that can be observed only in situations similar to the original one. Several other studies (Henderson, 1964; Lindzey et al., 1963; Levine and Broadhurst, 1963) indicate that the effects of prior treatment have considerable generality. Because of the sequential nature of the emotionality battery it was impossible to make an estimate of the extent to which the effects of prior treatment may have diminished with the passage of time. However since the effects due to treatment are evident in the underwater swimming task within the BALB/cJ strain, it may be assumed that the sequential nature of the battery is not sufficient to eliminate differences due to treatment. Other studies

Henderson, 1964; Lindzey et al., 1960, 1963; Hall & Whiteman, 1951) suggest that there may be a diminishing of treatment effects over time. However in this study, the sequential nature of the tasks and the short time-span of the battery, do not allow a comparison with the above studies and leaves the question concerning the duration of prior treatment effects as problematic.

2. The results of this study indicate strain differences between the SWR/J and BALB/cJ mice on all measures of emotionality except avoidance performance. The SWR/J strain has consistently shorter latencies, higher activity levels and lower elimination rates than the BALB/cJ strain, except on the activity wheel and intertrial activity (avoidance conditioning) measures, where the BALB/cJ strain has higher activity levels than the SWR/J strain. The important finding from the point of view of early experience research is the fact that these strain differences attain significant values on all measures, except underwater swimming, primarily under conditions of response to prior treatment. In underwater swimming the strain difference is greatest under the control condition and is reduced under conditions of prior treatment. These differential effects depending on strain, are consistent with the findings of King and Eleftheriou (1959) and Gauron (1964) that prior stimulation produced a modification in adaptibility to stress and that the nature of this modification is specific to the strain of the animal.

3. The essential question which remains is whether the two sets of determinants, genotype and the effects of prior stimulation, show any interaction. Are the changes in behavior that can be attributed to prior treatment in part dependent upon the gene structure of the organism undergoing the experience? The results of this study strongly suggest a differential effect of genotype upon the relation between prior treatment and later behavior. The effect is tenuous insofar as it is indicated on a select number of measures (activity and defecation in the open field and straightaway; and particularly on latency measures in the straightaway and stovepipe). These results support other studies (Gauron, 1964; Levine and Broadhurst, 1963; Lindzey et al, 1963; King and Eleftheriou, 1959) which provide only limited evidence for a differential interaction of environmental and hereditary variables. This study then adds to the scant evidence for such a differential interaction which is presumably a first approximation and would require a more refined design to evaluate the respective components of variability of each.

Behavior pattern of SWR/J strain

The two strains, SWR/J and BALB/cJ, employed in this study were chosen on the basis of the difference in their factor scores on three factors of emotionality (table, 1). The BALB/cJ strain indicates a high rate of defecation and low level of activity (cf Thompson, 1953) and may be considered the "high emotional" strain. The SWR/J strain indicates a low rate of defecation and high level of activity (cf

Thompson, 1953; Southwick and Clark, 1966) and may be considered the "low emotional" strain. These two strains were also found to differ in avoidance performance (Royce and Covington, 1960). The superior avoidance performance of the SWR/J strain was assumed to be characteristic of its low-emotional and efficient mode of adaptation to stress. Conversely, the poor avoidance performance of the BALB/cJ strain was assumed to be characteristic of its high-emotional and inefficient mode of adaptation (lability) to stress. Laboratory observations on these two strains indicated differences in their mode of emotional reactivity to everyday handling. The SWR/J mouse is extremely active while the BALB/cJ mouse remains passive and crouched in one place. Both these behaviors, interpreted as "escape" and "freezing" respectively, were assumed to be indices of emotional reactivity and to reflect modes of adaptation consistent with avoidance performance and the behavioral indices of the factor scores. With respect to these initial behavior considerations, it was expected that the mode of adaptation on the six dependent tasks, under the various treatment conditions, should present a consistent behavior pattern for each of the two strains.

The SWR/J strain appears to present such a consistent behavior pattern. This strain has short latencies on underwater swimming, stovepipe, straightaway and open field measures; high activity and penetration on straightaway and open field measures; low activity on activity wheel and intertrial activity (avoidance conditioning) measures and low rates

of defecation and urination on stovepipe, straightaway and open field measures. It is evident that there are two activity patterns (open field and straightaway measures and activity wheel and intertrial activity measures), and it may be speculated that these are different <u>dimensions</u> of emotionality mediated by different physiological mechanisms. The effect of increasing the intensity of prior treatment, from the non-disturb baseline, is as follows: there is a gradual increase in activity and penetration and a gradual decrease in latency in the open field and straightaway. However there are no treatment effects evident on elimination measures, on activity wheel or intertrial activity measures, on underwater swimming and stovepipe latency measures. The absence of treatment effects, depending on the nature of the task, would appear to support the evidence that the concept of emotionality or emotional reactivity is more than just a single process. Of course it may be simply concluded that open field and straightaway latency and activity measures are more sensitive measures of emotionality than the elimination measures (Gauron, 1964). However, even if this were the case, conceptually the former "motor-discharge" measures may be dimensionally distinct (perhaps physiologically) from the elimination measures as well as the latency and activity measures in the stovepipe, activity wheel, avoidance conditioning, and underwater swimming. If the elimination measures are valid measure of emotionality and the techniques used in this study are reliable (both assumptions find support

in the literature), then the effects of increasing the intensity of prior stimulation are negligible with respect to this dimension of emotionality in the SWR/J strain. If the motor-discharge measures present another reliable dimension of emotionality, the effect of increasing prior stimulation is to reduce emotionality (increase activity and decrease latency) in accordance with the predictions of Levine (1956) and Denenberg (1964). The mode of adaptation of the low-emotional SWR/J strain may be characterized by "immediate activity". Conceptually, three possible dimensions of emotionality have been identified: 1. elimination (change in rate of defecation and urination); 2. motor-discharge (change in level of activity and length of latency); 3. locomotor activity (change in level of non-exploratory, repetitive activity, (e.g. activity wheel and intertrial activity). For the SWR/J strain, the effect of increasing prior stimulation is evident only on the motor discharge dimension.

Behavior pattern of the BALB/cJ strain

The BALB/cJ strain has long latencies on underwater swimming, stovepipe, straightaway and open field measures; low activity and penetration on straightaway and open field measures; high activity on activity wheel and intertrial activity measures; high defecation and urination rates on stovepipe, straightaway and open field measures over all treatment conditions. Again there is evidence for two activity patterns which are the inverse activity patterns of

[illegible]

[illegible]

[illegible]

the SWR/J strain. The effect of increasing the intensity of prior treatment, from the control baseline, is in the same direction as the effect of sensory deprivation (non-disturb treatment condition). The effect of prior treatment (non-disturb, shock 1, 2) is to increase latency length in the stovepipe and straightaway; decrease latency in underwater swimming and open field; increase activity and penetration in the straightaway and open field, and increase defecation in the straightaway and open field. There is no evidence of treatment effects on activity wheel and intertrial activity measures or on stovepipe elimination measures. For the BALB/cJ strain it is clear that the defecation measures are as sensitive to the effects of prior treatment as are the activity and latency measures. Considering the defecation and latency measures, it may be concluded that the effect of prior treatment is to increase emotional reactivity in the BALB/cJ strain and support the positions of Lindzey et al., (1963; 1960); Bovard (1958) and Hall and Whiteman (1951). However the increase in activity and penetration does not fit this conceptual framework unless it is assumed that activity is a "motor discharge" or "escape" measure and the result of high emotional reactivity, rather than an "exploration measure. The similar increase in both defecation and activity (under conditions of prior treatment), rather than the expected emotionality changes, (i.e) an increase in the former and a decrease in the latter, suggests that these measures are getting at distinct dimensions of emotionality.

This supports the two dimensions posited on the basis of the decrease in latency (increase in activity) and absence of treatment on the defecation measures for the SWR/J strain. The mode of adaptation of the BALB/cJ strain may be characterized by reactivity (defecation), freezing and motor discharge (latency and activity). There are two difficulties with this interpretation, first, the decrease in latency in the open field, second, the decrease in latency in underwater swimming under conditions of prior treatment. In the case of the latter it may be assumed that the stressful nature of the task eliminates the highly unadaptive initial freezing period and initiates immediately motor-discharge behavior. However, the problem of the decrease in latency in the open field remains unanswered. It may be concluded that the high emotional BALB/cJ strain increases emotional reactivity under conditions of prior treatment evident on measures of elimination and motor discharge. The absence of treatment effects on the locomotor measures (activity wheel and intertrial activity) is consistent with SWR/J strain behavior. For the BALB/cJ strain, the effects of prior treatment (non-disturb, shock 1, 2) are evident both the elimination and the motor-discharge dimensions of emotionality.

Theoretical considerations

The distinctions among certain dimensions of emotionality (elimination, motor discharge, locomotor activity) finds considerable support in the factor analytic literature (e.g.) Royce (1966 b). In a summary of this

literature Royce indicates two factors in particular that have been independently identified most frequently: factor P, designated by Wenger (1948) as "autonomic balance" and by Cattell (1950) as "general autonomic activity", and factor Q, designated as "motor discharge" by Freeman (1942).

The behavioral components (together with the physiological variables) suggest that factor P is an emotional (autonomic) discharge factor. Defecation and urination load heavily on this factor (McClearn and Meredith, 1964; Willingham, 1956; Billingslea, 1942). There need not be a commitment to the notion of autonomic balance (Wenger) to be able to view this factor as one of sympathetic arousal.

Factor Q is primarily characterized behaviorally by motor activity in a wide variety of situations. Freeman (1942) terms this a "discharge control" factor and the organism high on this factor effects rapid recovery after sympathetic arousal primarily via motor discharge of such energy. Royce (1955) found a timidity factor (factor H) which is in agreement with factor Q and characterized by withdrawal (freezing) and hyperactivity. A difficulty concerning the interpretation of factor Q revolves around timidity (Royce, 1955) as it might relate to muscle tension (Wenger, 1948). It is conceivable that the linkage between the motor-discharge (Royce) and the muscle tension (Wenger) is provided via the behavior pattern of freezing. The energy available for motor discharge and the inhibitory effect reflected in withdrawal and freezing could lead to a

state of muscular tension. In this study such an explanation is consistent with BALB/cJ strain behavior.

Finally, Royce mentions a third factor R, which has not been replicated sufficiently, but has been termed an activity level factor. Factor R appears to be the locomotor activity dimension in this study. A wide variety of measures have been found to load on this factor, particularly measures of activity under restraint and activity in a maze (McClearn and Meredith, 1964).

It is possible to see correspondences between the results of the factor analytic studies and the behavior patterns of the two strains in this study. Increasing the intensity of prior treatment (from non-disturb baseline) has effects primarily evident on the motor-discharge dimension for the low emotional SWR/J strain. Prior treatment (from the control baseline) has effects on both the elimination and the motor discharge dimensions for the high emotional BALB/cJ strain. Strain differences but not treatment effects are evident on the locomotor activity dimension. Regardless of the physiological mediating mechanisms, this study provides strong evidence for at least two behavioral dimensions of emotionality and perhaps a third: elimination, motor discharge, and locomotor activity. Such "clustering" of behavioral indices should give warning to the mere listing of behavioral measures as evidence for the effect of prior stimulation on emotionality. For example, the high activity measure has usually

been interpreted as exploratory behavior and considered an index of low-emotionality, however as indicated, an increase in activity may also indicate an increase in emotionality depending on its relation to latency and defecation measures. Activity, in this study, is consequently interpreted as motor discharge behavior. Such terms as "exploratory" behavior or "escape" behavior should be employed sparingly, as they do not account for the multi-dimensionality of emotionality.

<u>Conclusions</u>

With regard to the specific predictions made in the introduction (page, 19), the following may be concluded. The effect of prior treatment (increasing shock intensity and the non-disturb treatment condition) was to increase emotional reactivity in the high-emotional BALB/cJ strain. Operationally, the increase in activity does not fit the conceptualizations of Lindzey et al., (1963) but is in accordance with the findings of King and Eleftheriou (1959) using mice and Levine and Broadhurst (1963) and Gauron (1964) using rats.

The effect of prior treatment (from the non-disturb baseline) was to decrease emotional reactivity in the low-emotional SWR/J strain. Operationally, there was an increase in activity and a decrease in latency ("immediate activity") which would indicate a more efficient mode of adaptation. These findings support the conceptualizations of Levine (1956) and Denenberg (1964). The absence of treatment

effects on the elimination measures have been found in a number of studies (Henderson, 1967; Gauron,1964) which otherwise support this position.

The finding that differences in the mode of adaptation become more pronounced under conditions of prior manipulation has certain implications. A special concern of behavior-genetics is the avoidance of non-random association between environmental and hereditary factors. In this study care has been taken to avoid such associations and the systematic and controlled introduction of post-weaning manipulation would suggest that differences in the expression of emotionality are to a large extent dependent on environmental factors. That is, the differences in the expression of emotionality become evident primarily in response to post-weaning environmental pressure. This points to the care required in selecting environmental factors that "complete" the process of gene encoding and differentiation of the organism. Furthermore, it indicates that research in the area of emotionality is closely tied to developmental psychology.

The examination of these results suggests further research is required, particularly concerning the validity and meaning of certain measures, and the relationship among behavioral dimensions of emotionality, as well as their relation to physiological mediating mechanisms. The results of this study should give warning against any simplistic account of emotionality.

Summary and Conclusions

The purpose of this study was to establish a relationship between post-weaning stimulation and later emotionality and to clarify the effects due to strain, treatment and strain by treatment.

Four independent conditions of post-weaning manipulation were employed: non-disturb, control, shock 1, and shock 2. A battery of dependent tasks, purported measures of emotionality, was administered at some later time. The following is a summary of the results.

1. Not all tasks were found to be sensitive measures of differences in emotionality. Open field, straightaway, stovepipe and underwater swimming tasks were sensitive measures but avoidance conditioning and activity wheel were not.

2. The "high emotional" BALB/cJ strain showed higher rates of defecation and urination, longer latencies and lower levels of activity than the "low emotional" SWR/J strain over all treatment conditions.

3. The "low emotional" SWR/J strain increased activity and decreased latency under conditions of prior treatment (motor discharge). There was no effect due to treatment on measures of elimination for the SWR/J strain.

4. The "high emotional" BALB/cJ strain increased defecation, latency and activity under conditions of prior treatment (elimination).

5. On the avoidance conditioning and activity wheel measures the BALB/cJ strain showed a high level of activity, while the SWR/J strain showed a low level of activity (locomotor activity). Avoidance conditioning performance improved for the BALB/cJ strain but declines for the SWR/J strain under conditions of prior treatment.

6. The mode of adaptation under conditions of prior treatment, was different for the two strains. The "high-emotional" BALB/cJ strain increased emotionality and its behavior was characterized by an initial "freezing" period followed by "escape" behavior. The "low emotional" SWR/J strain reduced emotionality and its behavior was characterized by "immediate activity" or exploration" behavior.

7. Examination of the various measures revealed three dimensions of emotionality 1. elimation, 2. motor discharge 3. locomotor activity.

8. Finally a word concerning the behavioral differences due to sex. The only sex differences were found in the BALB/cJ strain (cf Henderson, 1967). Females of this strain were found to have a higher defecation and urination rate (open field, straightaway and stovepipe) and longer latencies (underwater swimming) than males. Such sex differences have been found elsewhere (Lester, 1968) but the findings have been rather inconsistent and seem only to add to the complexity of the effects due to strain and treatment.

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Appendix A

Open field

Open field activity (strain x treatment)

	ND	CON	S1	S2
SWR/J	39.85	63.15	84.40	124.50
BALB/cJ	52.10	25.95	35.20	45.65

Open field latency (strain x treatment)

	ND	CON	S1	S2
SWR/J	11.02	12.37	4.11	4.98
BALB/cJ	13.52	10.86	7.94	6.69

Open field defecation (strain x treatment)

	ND	CON	S1	S2
SWR/J	.3	1.15	.95	.30
BALB/cJ	4.2	1.55	3.05	4.80

Open field defecation (strain x sex)

	Male	Female
SWR/J	.625	.725
BALB/cJ	2.620	4.175

Open field penetration (strain x treatment)

	ND	CON	S1	S2
SWR/J	3.30	1.75	3.40	4.00
BALB/cJ	1.20	1.55	2.40	2.45

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Straightaway

Straightaway activity (strain x treatment)

	ND	CON	S1	S2
SWR/J	42.70	62.60	90.55	115.60
BALB/cJ	70.20	42.75	60.90	82.55

Straightaway latency (strain x treatment)

	ND	CON	S1	S2
SWR/J	7.24	6.86	3.70	2.22
BALB/cJ	5.16	7.31	10.42	15.67

Straightaway defecation (strain x treatment)

	ND	CON	S1	S2
SWR/J	.25	1.40	.25	.10
BALB/cJ	5.10	1.95	2.65	3.35

Stovepipe

Stovepipe, enter 1, (strain x treatment)

	ND	CON	S1	S2
SWR/J	5.80	4.26	4.14	4.27
BALB/cJ	16.15	11.18	13.27	22.84

Stovepipe, emerge 1, (strain x treatment)

	ND	CON	S1	S2
SWR/J	10.27	7.01	9.92	6.49
BALB/cJ	12.54	10.24	12.05	22.19

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Stovepipe

Stovepipe, enter 2, (strain x treatment)

	ND	CON	S1	S2
SWR/J	4.30	3.74	2.95	3.28
BALB/J	13.94	3.28	13.03	26.04

Stovepipe, emerge 2, (strain x treatment)

	ND	CON	S1	S2
SWR/J	9.15	6.84	6.83	5.26
BALB/cJ	11.85	6.35	12.37	21.50

Activity Wheel

Activity wheel (strain x treatment)

	ND	CON	S1	S2
SWR/J	767.37	1468.30	1256.60	1793.80
BALB/cJ	2777.80	1838.10	2549.10	3960.40

Avoidance conditioning

Avoidance conditioning (strain x treatment)

	ND	CON	S1	S2
SWR/J	12.00	14.26	13.83	12.63
BALB/cJ	15.23	11.46	12.63	14.13

Intertrial activity (strain x treatment)

	ND	CON	S1	S2
SWR/J	42.93	47.76	29.10	66.66
BALB/cJ	98.66	78.16	107.40	148.93

Avoidance conditioning

	SWR/J (session) 1	2	3	BALB/cJ(session) 1	2	3
ND	6.10	10.60	19.30	9.70	14.70	21.30
CON	6.50	15.20	21.10	4.70	13.80	15.90
S1	7.80	13.30	20.40	6.30	11.30	20.30
S2	6.40	11.70	19.80	7.20	15.70	19.50

Underwater swimming

Underwater swimming, measure 1, (strain x treatment)

	ND	CON	S1	S2
SWR/J	.36	.34	.38	.39
BALB/cJ	.41	.44	.40	.35

Underwater swimming, measure 2, (strain x treatment)

	ND	CON	S1	S2
SWR/J	.79	.68	.76	.68
BALB/cJ	1.18	1.57	1.16	.96

Underwater swimming, measure 3, (strain x treatment)

	ND	CON	S1	S2
SWR/J	1.38	1.23	1.14	1.21
BALB/cJ	1.35	1.57	1.36	1.25